EXHIBIT 8

UNITED STATES DISTRICT COURT
FOR THE EASTERN DISTRICT OF TEXAS
MARSHALL DIVISION

ENTROPIC COMMUNICATIONS, LLC,

Plaintiff

v.

CHARTER COMMUNICATIONS, INC.

Defendant.

Civil Action No. 2:22-cv-00125-JRG

DECLARATION OF DR. KEVIN ALMEROTH
REGARDING CLAIM CONSTRUCTION

I, Kevin C. Almeroth, declare as follows:

I. QUALIFICATIONS

1. I am currently a Professor Emeritus in the Department of Computer Science at the University of California, Santa Barbara (UCSB). While at UCSB, I held faculty appointments and was a founding member of the Computer Engineering (CE) Program, Media Arts and Technology (MAT) Program, and the Technology Management Program (TMP). I also served as the Associate Director of the Center for Information Technology and Society (CITS) from 1999 to 2012. I have been a faculty member at UCSB since July 1997.

2. I hold three degrees from the Georgia Institute of Technology: (1) a Bachelor of Science degree in Information and Computer Science (with minors in Economics, Technical Communication, and American Literature) earned in June 1992; (2) a Master of Science degree in Computer Science (with specialization in Networking and Systems) earned in June 1994; and (3) a Doctor of Philosophy (Ph.D.) degree in Computer Science (Dissertation Title: Networking and System Support for the Efficient, Scalable Delivery of Services in Interactive Multimedia System, minor in Telecommunications Public Policy) earned in June 1997. During my education, I have taken a wide variety of courses as demonstrated by my minor. My undergraduate degree also included a number of courses more typical of a degree in electrical engineering including digital logic, signal processing, and telecommunications theory.

3. One of the major concentrations of my research over the past 30+ years has been the delivery of multimedia content and data between computing devices, including various network architectures. In my research, I have studied large-scale content delivery systems, and the use of servers located in a variety of geographic locations to provide scalable delivery to hundreds or thousands of users simultaneously. I have also studied smaller-scale content delivery systems in

which content is exchanged between individual computers and portable devices. My work has emphasized the exchange of content more efficiently across computer networks, including the scalable delivery of content to many users, mobile computing, satellite networking, delivering content to mobile devices, and network support for data delivery in wireless networks.

4. In 1992, the initial focus of my research was on the provision of interactive functions (e.g., VCR-style functions like pause, rewind, and fast-forward) for near video-on-demand systems in cable systems; in particular, how to aggregate requests for movies at a cable head-end and then how to satisfy a multitude of requests using one audio/video stream broadcast to multiple receivers simultaneously. This research has continually evolved and resulted in the development of techniques to scalably deliver on-demand content, including audio, video, web documents, and other types of data, through the Internet and over other types of networks, including over cable systems, broadband telephone lines, and satellite links.

5. An important component of my research has been investigating the challenges of communicating multimedia content, including video, between computers and across networks including the Internet. Although the early Internet was used mostly for text-based, non-real time applications, the interest in sharing multimedia content, such as video, quickly developed. Multimedia-based applications ranged from downloading content to a device to streaming multimedia content to be instantly used. One of the challenges was that multimedia content is typically larger than text-only content, but there are also opportunities to use different delivery techniques since multimedia content is more resilient to errors. I have worked on a variety of research problems and used a number of systems that were developed to deliver multimedia content to users. One content-delivery method I have researched is the one-to-many communication facility called "multicast," first deployed as the Multicast Backbone, a virtual overlay network supporting one-to-many

communication. Multicast is one technique that can be used on the Internet to provide streaming media support for complex applications like video-on-demand, distance learning, distributed collaboration, distributed games, and large-scale wireless communication. The delivery of media through multicast often involves using Internet infrastructure, devices and protocols, including protocols for routing and TCP/IP.

6. Starting in 1997, I worked on a project to integrate the streaming media capabilities of the Internet together with the interactivity of the web. I developed a project called the Interactive Multimedia Jukebox (IMJ). Users would visit a web page and select content to view. The content would then be scheduled on one of a number of channels, including delivery to students in Georgia Tech dorms delivered via the campus cable plant. The content of each channel was delivered using multicast communication.

7. In the IMJ, the number of channels varied depending on the capabilities of the server including the available bandwidth of its connection to the Internet. If one of the channels was idle, the requesting user would be able to watch their selection immediately. If all channels were streaming previously selected content, the user's selection would be queued on the channel with the shortest wait time. In the meantime, the user would see what content was currently playing on other channels, and because of the use of multicast, would be able to join one of the existing channels and watch the content at the point it was currently being transmitted.

8. The IMJ service combined the interactivity of the web with the streaming capabilities of the Internet to create a jukebox-like service. It supported true Video-on-Demand when capacity allowed, but scaled to any number of users based on queuing requested programs. As part of the project, we obtained permission from Turner Broadcasting to transmit cartoons and other short-subject content. We also connected the IMJ into the Georgia Tech campus cable television network

so that students in their dorms could use the web to request content and then view that content on one of the campus's public access channels.

9. More recently, I have also studied issues concerning how users choose content, especially when considering the price of that content. My research has examined how dynamic content pricing can be used to control system load. By raising prices when systems start to become overloaded (*i.e.*, when all available resources are fully utilized) and reducing prices when system capacity is readily available, users' capacity to pay as well as their willingness can be used as factors in stabilizing the response time of a system. This capability is particularly useful in systems where content is downloaded or streamed on-demand to users.

10. As a parallel research theme, starting in 1997, I began researching issues related to wireless devices and sensors. In particular, I was interested in showing how to provide greater communication capability to "lightweight devices," *i.e.*, small form-factor, resource-constrained (*e.g.*, CPU, memory, networking, and power) devices. Starting in 1998, I published several papers on my work to develop a flexible, lightweight, battery-aware network protocol stack. The lightweight protocols we envisioned were similar in nature to protocols like Bluetooth, Universal Plug and Play (UPnP) and Digital Living Network Alliance (DLNA).

11. From this initial work, I have made wireless networking—including ad hoc, mesh networks and wireless devices—one of the major themes of my research. My work in wireless networks spans the protocol stack from applications through to the encoding and exchange of data at the data link and physical layers.

12. At the application layer, even before the large-scale "app stores" were available, my research looked at building, installing, and using apps for a variety of purposes, from network monitoring to support for traditional computer-based applications (*e.g.,* content retrieval) to new

applications enabled by ubiquitous, mobile devices. For example, my research has looked at developing applications for virally exchanging and tracking "coupons" through "opportunistic contact" (*i.e.*, communication with other devices coming into communication range with a user). In many of the courses I have taught there is a project component. Through these projects I have supervised numerous efforts to develop new "apps" for download and use across a variety of mobile platforms.

13. Toward the middle of the protocol stack, my research also looked to build wireless infrastructure support to enable communication among a set of mobile devices unaided by any other kind of network infrastructure. These kinds of networks are useful either in challenged network environments (e.g., when a natural disaster has destroyed existing infrastructure) or when suitable support for network communication never existed. The deployment of such networks (or even the use of traditional network support) are critical to support services like disaster relief, catastrophic event coordination, and emergency services deployment.

14. Yet another theme is monitoring wireless networks, in particular different variants of IEEE 802.11 compliant networks, to (1) understand the operation of the various protocols used in real-world deployments, (2) use these measurements to characterize use of the networks and identify protocol limitations and weaknesses, and (3) propose and evaluate solutions to these problems. I have successfully used monitoring techniques to study wireless data link layer protocol operation and to improve performance by enhancing the operation of such protocols. For wireless protocols, this research includes functions like network acquisition and channel bonding.

15. Protecting networks, including their operation and content, has been an underlying theme of my research almost since the beginning of my research career. Starting in 2000, I have been involved in several projects that specifically address security, network protection, and firewalls. After

significant background work, a team on which I was a member successfully submitted a $4.3M grant proposal to the Army Research Office (ARO) at the Department of Defense to propose and develop a high-speed intrusion detection system. Key aspects of the system included associating streams of packets and analyzing them for viruses and other malware. Once the grant was awarded, we spent several years developing and meeting the milestones of the project. A number of my students worked on related projects and published papers on topics ranging from intrusion detection to developing advanced techniques to be incorporated into firewalls. I have also used firewalls, including their associated malware detection features, in developing techniques for the classroom to ensure that students are not distracted by online content.

16. My recent work ties some of the various threads of my past research together. I have investigated content delivery in online social networks and proposed reputation management systems in large-scale social networks and marketplaces. On the content delivery side, I have looked at issues of caching and cache placement, especially when content being shared and the cache has geographical relevance. We were able to show that effective caching strategies can greatly improve performance and reduce deployment costs. Our work on reputation systems showed that reputations have economic value, and as such, creates a motivation to manipulate reputations. In response, we developed a variety of solutions to protect the integrity of reputations in online social networks. The techniques we developed for content delivery and reputation management were particularly relevant in peer-to-peer communication and recommendations for downloadable "apps."

17. As an important component of my research program, I have been involved in the development of academic research into available technology in the market place. One aspect of this work is my involvement in the Internet Engineering Task Force (IETF). The IETF is a large and open international community of network designers, operators, vendors, and researchers concerned with

the evolution of the Internet architecture and the smooth operation of the Internet. I have been involved in various IETF groups including many content delivery-related working groups like the Audio Video Transport (AVT) group, the MBone Deployment (MBONED) group, Source Specific Multicast (SSM) group, the Inter-Domain Multicast Routing (IDMR) group, the Reliable Multicast Transport (RMT) group, the Protocol Independent Multicast (PIM) group, etc. I have also served as a member of the Multicast Directorate (MADDOGS), which oversaw the standardization of all things related to multicast in the IETF. Finally, I was the Chair of the Internet2 Multicast Working Group for seven years.

18. My involvement in the research community extends to leadership positions for several academic journals and conferences. I am the co-chair of the Steering Committee for the ACM Network and System Support for Digital Audio and Video (NOSSDAV) workshop and on the Steering Committees for the International Conference on Network Protocols (ICNP), ACM Sigcomm Workshop on Challenged Networks (CHANTS), and IEEE Global Internet (GI) Symposium. I have served or am serving on the Editorial Boards of IEEE/ACM Transactions on Networking, IEEE Transactions on Mobile Computing, IEEE Network, ACM Computers in Entertainment, AACE Journal of Interactive Learning Research (JILR), and ACM Computer Communications Review. I have co-chaired a number of conferences and workshops including the IEEE International Conference on Network Protocols (ICNP), IEEE Conference on Sensor, Mesh and Ad Hoc Communications and Networks (SECON), International Conference on Communication Systems and Networks (COMSNETS), IFIP/IEEE International Conference on Management of Multimedia Networks and Services (MMNS), the International Workshop On Wireless Network Measurement (WiNMee), ACM Sigcomm Workshop on Challenged Networks (CHANTS), the Network Group Communication (NGC) workshop, and the Global Internet Symposium, and I have served on the

program committees for numerous conferences.

19. Furthermore, in the courses I taught at UCSB, a significant portion of my curriculum covered aspects of the Internet and network communication including the physical and data link layers of the Open System Interconnect (OSI) protocol stack, and standardized protocols for communicating across a variety of physical media such as cable systems, telephone lines, wireless, and high-speed Local Area Networks (LANs), including DOCSIS. The courses I have taught also cover most major topics in Internet communication, including data communication, multimedia encoding, and mobile application design. My research and courses have covered a range of physical infrastructures for delivering content over networks, including cable, Integrated Services Digital Network (ISDN), Ethernet, Asynchronous Transfer Mode (ATM), fiber, and Digital Subscriber Line (DSL). For a complete list of courses I have taught, see my curriculum vitae (CV).

20. In addition, I co-founded a technology company called Santa Barbara Labs that was working under a sub-contract from the U.S. Air Force to develop very accurate emulation systems for the military's next generation internetwork. Santa Barbara Labs' focus was in developing an emulation platform to test the performance characteristics of the network architecture in the variety of environments in which it was expected to operate, and, in particular, for network services including IPv6, multicast, Quality of Service (QoS), satellite-based communication, and security. Applications for this emulation program included communication of a variety of multimedia-based services, including video conferencing and video-on-demand.

21. In addition to having co-founded a technology company myself, I have worked for, consulted with, and collaborated with companies for nearly 30 years. These companies range from well-established companies to start-ups and include IBM, Hitachi Telecom, Turner Broadcasting System (TBS), Bell South, Digital Fountain, RealNetworks, Intel Research, Cisco Systems, and

Lockheed Martin.

22. Through my graduate education, leadership with CITS, involvement in TMP, role in the development of the Internet2 infrastructure, and consulting with ISPs, I have gained a strong understanding in the role of the Internet in our society and the challenges of deploying large-scale production networking infrastructure. CITS, since its inception, has looked at the role of the Internet in society, including how the evolution of technology have created communication opportunities and challenges, including, for example through disruptive technologies like P2P. TMP looks to focus on non-purely technical issues, including, for example, state-of-the-art business methods, strategies for successful technology commercialization, new venture creation, and best practices for fostering innovation. Through my industry collaborations and Internet2 work, I have developed significant experience in the challenges of deploying, monitoring, managing, and scaling communication infrastructure to support evolving Internet services like streaming media, conferencing, content exchange, social networking, and e-commerce.

23. I am a Member of the Association of Computing Machinery (ACM) and a Fellow of the Institute of Electrical and Electronics Engineers (IEEE).

24. Additional details about my employment history, fields of expertise, courses taught, and publications are further included in my CV attached as Appendix A to this Declaration.

II. MATERIALS CONSIDERED AND COMPENSATION

25. In preparing this declaration, I reviewed U.S. Patent Nos. 8,223,775 (the "'775 Patent"), 8,284,690 (the "'690 Patent") and 10,135,682 (the "'682 Patent"), including the claims of these patents. I have also reviewed the prosecution histories of these patents and the other materials referenced in this declaration.

26. I am being compensated at the rate of $800 per hour. My opinions are objective, and

compensation for my services is not contingent on my opinions or the outcome of this action.

III. LEVEL OF ORDINARY SKILL IN THE ART

27. A person of ordinary skill in the art ("POSITA") would be a person having at least: i) a bachelor-level degree in electrical engineering or a related subject and three or more years of experience working in the field of cable television signal processing and communication systems; ii) a master's-level degree in electrical engineering or a related subject and one or more years of experience working in the field of cable television signal processing and communication systems; or iii) a Ph.D.-level degree in electrical engineering or a related subject and at least some experience working in the field of cable television signal processing and/or communication systems. Additional education may substitute for professional experience, and significant work experience may substitute for formal education.

IV. SUMMARY OF MY OPINIONS

28. For purposes of this declaration, I have been asked to render opinions only with respect to certain claim terms in the '775, '690 and '682 Patents. For convenience, I use the nomenclature "claim term" to refer to individual claim terms as well as entire claim phrases.

29. The claim terms in the '775 Patent on which I was asked to opine appear in claim 18 of that patent. The following chart identifies those terms and a summary of my opinions with respect to those terms:

'775 Patent Claim 18 Term	**Summary Of My Opinions**
"a data networking engine implemented in a first circuit that includes at least one processor, the data networking engine programmed with software that when executed by the at least one processor of the first circuit causes the data networking engine to perform home networking functions including interfacing with customer provided equipment"	This claim term renders claim 18 and its dependents indefinite because there is no way to determine what "circuit" means in the claims or how many circuits a particular cable modem contains. Nor is there a way to determine where one circuit begins and another ends. It is therefore impossible to determine if any particular cable modem contains "a first circuit" and "a second circuit' as claimed, or if the "second circuit" is "separate from the first circuit."
"a cable modem engine implemented in a second circuit that includes at least one processor, the second circuit being separate from the first circuit, the cable modem engine programmed with software that when executed by the at least one processor of the second circuit causes the cable modem engine to perform cable modem functions other than the home networking functions performed by the data networking engine, the cable modem functions including interfacing with cable media"	This claim term renders claim 18 and its dependents indefinite because there is no way to determine what "circuit" means in the claims or how many circuits a particular cable modem contains. Nor is there a way to determine where one circuit begins and another ends. It is therefore impossible to determine if any particular cable modem contains "a first circuit" and "a second circuit' as claimed, or if the "second circuit" is "separate from the first circuit."
"DOCSIS MAC processor"	If "DOCSIS MAC processor" does not mean the DOCSIS MAC processor as described in the patent specification (*see, e.g.*, '775 Patent, at 3:1-20; 4:41-57; *id.*, at Figures 1 & 2), then it is indefinite. "DOCSIS MAC processor" does not have a plain and ordinary meaning (the DOCSIS specifications do not define this term nor is there a commonly accepted meaning in the industry.)
"DOCSIS controller"	If "DOCSIS controller" does not mean the DOCSIS controller as described in the patent specification (*see, e.g.*, '775 Patent, at 3:21-48; 4:41-57; *id.*, at Figures 1 & 2), then it is indefinite. "DOCSIS controller" does not have a plain and ordinary meaning (the DOCSIS specifications do not define this term nor is there a commonly accepted meaning in the industry.)

‘775 Patent Claim 18 Term	Summary Of My Opinions
“data bus”	The claim limitation requiring “a data bus that connects the data networking engine to the cable modem engine, wherein the cable modem functions performed by the cable modem engine are completely partitioned from the home networking functions performed by the data networking engine” renders claim 18 and its dependents indefinite. The applicants successfully argued during prosecution that a “data networking engine” and a “cable modem engine” are not “completely partitioned” if they share “connecting circuitry” or “data paths.” The “data bus” as claimed would be shared “connecting circuitry” and a shared “data path,” meaning the cable modem engine and the data networking engine cannot be “completely partitioned” as claimed.

30. The claim terms in the ’690 Patent on which I was asked to opine appear in claims 1 and 9 of that patent. The following chart identifies those terms and a summary of my opinions with respect to those terms:

’690 Patent Claim 1 Term	Summary Of My Opinions
“generating the probe in accordance with the first plurality of parameters and the second plurality of parameters, wherein the probe has a form dictated by the first plurality of parameters”	Claim 1 of the ’690 Patent and its dependents are indefinite because “generating the probe in accordance with the first plurality of parameters and the second plurality of parameters” is incompatible with “wherein the probe has a form dictated by the first plurality of parameters.” By definition, the parameters define the form of a probe. A probe cannot be generated in accordance with the “first plurality of parameters” and the “second plurality of parameters,” but have its form dictated only by the “first plurality of parameters” (as is covered by the claim.)

’690 Patent Claim 9 Term	Summary Of My Opinions
“wherein the probe is generated in accordance with the first plurality of parameters and in accordance with a second plurality of parameters determined by the second node”	Claim 9 of the ’690 Patent and its dependents are indefinite because “wherein the probe is generated in accordance with the first plurality of parameters and in accordance with a second plurality of parameters determined by the second node” is incompatible with “the first plurality of probe parameters comprising a form for the probe including a modulation profile for the probe.” By definition, the parameters define the form of a probe. A probe cannot be generated in accordance with the “first plurality of parameters” and the “second plurality of parameters,” but have only the “first plurality of parameters” comprise its form (as is covered by the claim.)
“the first plurality of probe parameters comprising a form for the probe including a modulation profile for the probe”	Claim 9 of the ’690 Patent and its dependents are indefinite because “wherein the probe is generated in accordance with the first plurality of parameters and in accordance with a second plurality of parameters determined by the second node” is incompatible with “the first plurality of probe parameters comprising a form for the probe including a modulation profile for the probe.” By definition, the parameters define the form of a probe. A probe cannot be generated in accordance with the “first plurality of parameters” and the “second plurality of parameters,” but have only the “first plurality of parameters” comprise its form (as is covered by the claim.)

31. The claim terms in the ’682 Patent on which I was asked to opine appear in claim 1 of that patent. The following chart identifies those terms and a summary of my opinions with respect to those terms:

’682 Patent Claim 1 Term	Summary Of My Opinions
“a composite SNR-related metric based at least in part on a worst-case SNR profile of said SNR-related metrics”	The asserted claims of the ’682 Patent are indefinite because neither “composite SNR-related metric” nor “worst-case SNR profile” have a plain and ordinary meaning. To the extent those terms standing alone are not indefinite, they must both refer to the disclosed “composite worst-case SNR profile.” In that event, however, the claims are indefinite because there is no way to know how the “composite SNR-related metric” can be “based *at least in part on*” the “worst-case SNR profile” since the two refer to the same thing.
“[communicating with/corresponding to] said one of said plurality of service groups”	The asserted claims of the ’682 Patent are indefinite because there is no identified or antecedent “one of said plurality of service groups” to which "said one of said plurality of service groups” refers.

V. THE ’775 PATENT

A. The Disclosure of the ’775 Patent

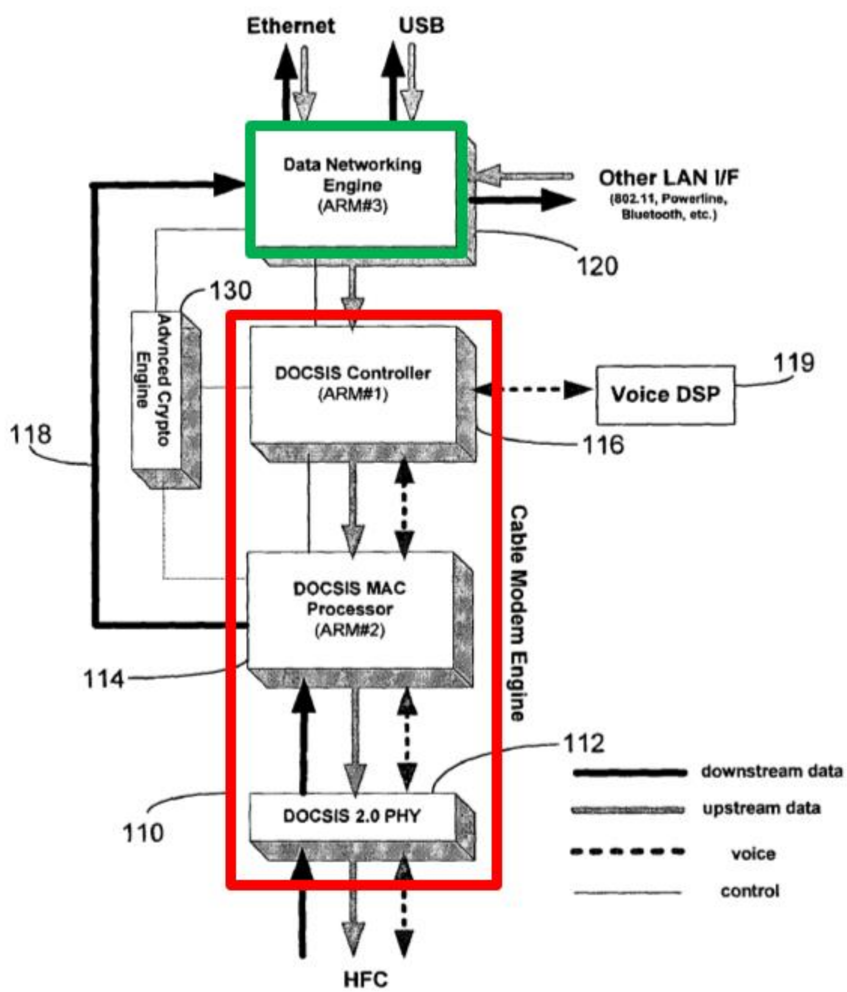
32. The ’775 Patent is titled “Architecture For A Flexible And High-Performance Gateway Cable Modem.” As the title suggests, the patent is directed to an allegedly novel architecture of a cable modem. (’775 Patent, 1:7-9.). A cable modem is a device in a cable customer’s home which provides the customer with access to the Internet over a cable television network. (*See, e.g.*, Appx. B, Excerpted Newton’s Telecom Dictionary (17th Ed. 2001), at 113.) The “architecture” of a computer-implemented device refers to how the device’s components are connected to, and operate with, each other. (*Id.*, at 55.)

33. In the case of the ’775 Patent, the alleged invention is a cable modem having a “functionally partitioned … architecture.” (’755 Patent, 1:8-9.) In other words, the cable modem is “partitioned” into discrete components, each of which is responsible for performing defined functions.

34. One way the disclosed cable modem is partitioned is its separation into a so-called

"cable modem engine" ("CME") and a so-called "data networking engine" ("DNE"). (*Id.*, 1:66-2:2.) I say "so-called" because these are not known terms in the art. A POSITA would know to rely on the specification's description of those "engines" to understand what they are.

35. Figure 1 of the '775 Patent "illustrates a cable modem system architecture 100 according to the present invention. System 100 comprises three major subsystems: cable modem engine 110; data networking engine 120; and advanced crypto engine 130." (*Id.*, 2:49-54.) Figure 1 of the patent is reproduced below. I have annotated the figure to show the DNE in green and the CME in red (the "advanced crypto engine" is not pertinent to my declaration):



36. The CME is responsible for all DOCSIS and VoIP/PacketCable functionality. (*Id.*, 2:23-24; 2:15-17; 4:19-21.) DOCSIS stands for "Data Over Cable Service Interface Specification,"

and is the cable industry standard that specifies functions and interfaces for transmission of digital data between cable networks and subscribers. (Appx. C, Excerpted Microsoft Computer Dictionary (5th Ed. 2002), at 171.) "VoIP" stands for "Voice over IP," and is a technology for sending/receiving voice communications over IP networks. (Appx. B, at 757.) PacketCable is a specification for implementing VoIP on a cable network. ('775 Patent, 2:15-19; Appx. D, "PACKETCABLE™ – CableLabs" (available at https://www.cablelabs.com/specifications-library/packetcable); Appx. E, PacketCable™ 1.0 Architecture Framework Technical Report (December 1, 1999), at 1.)

37. The DNE "implement[s] all data networking processing and home networking applications." ('775 Patent, 2:12-13.) "In one implementation…the data networking functionality provided by the data networking engine is in accordance with the CableHome specification." (*Id.*, 2:15-19.)

1. The Partitioning of the CME and DNE

38. The alleged invention of the '775 Patent is a cable modem that has a particular structure specified by the patent. The specification repeatedly emphasizes that a key aspect of this alleged invention is the "complete" partitioning of the DNE and CME within the cable modem:

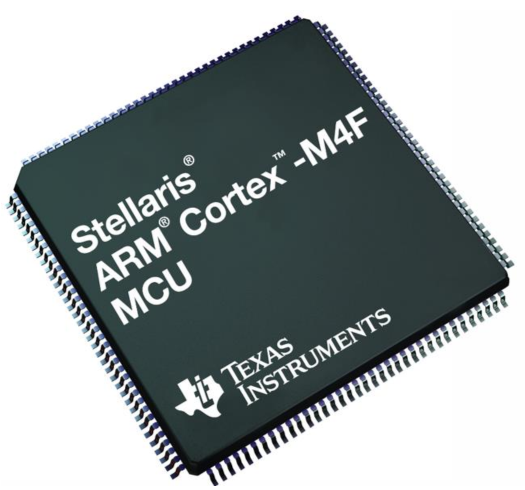
> One embodiment of the invention is a cable modem system comprising a data networking engine that performs data networking functions and a cable modem engine that performs all other cable modem functions, wherein the cable modem engine is ***completely partitioned*** from the data networking engine. (*Id.*, 1:66-2:4.)
>
> The data networking engine is ***completely decoupled*** from the cable modem engine. (*Id.*, 2:13-15.)
>
> The data networking engine is ***partitioned*** from the cable modem engine so that the data and home networking functionality is ***completely decoupled*** from the DOCSIS and VoIP functionality. (*Id.*, 2:24-27.)

> In one implementation, the entire embedded portal services (PS) functionality of the CableHome specification is contained within data networking engine **120**, with the CableHome functionality being ***completely decoupled*** from the PacketCable and DOCSIS functionality provided by cable modem engine **110**. (*Id.*, 3:53-58.)
>
> Cable modem **100** ***completely partitions*** data networking functions (advanced bridging/routing, NAT/firewall, VPN, web server and CableHome applications) from DOCSIS cable modem functionality. (4:13-16.)

39. However, the specification does not explain what constitutes "complete" partitioning or *how* the DNE and CME are completely partitioned. As I explain in paragraphs 57-63 below, this issue was raised during prosecution of the '775 Patent. The applicant successfully distinguished prior art by arguing that complete partitioning requires that the DNE and CME not share any connecting circuitry, data paths or memory devices.

2. The Structure of the DNE

40. The DNE constitutes one "ARM processor." (*Id.*, Fig 1; 4:48-49.) An ARM processor is an "Advanced RISC Machine" processor, which is a type of microprocessor that can be incorporated into computerized devices. (Appx. C at 35.) Below is a photograph of an ARM processor:



(Retrieved from Power Systems Design, "TI delivers leading analog integration, best-in-class low power and floating-point performance in new Stellaris® ARM® Cortex™-M4F microcontrollers" (*available at* https://www.powersystemsdesign.com/articles/ti-delivers-leading-analog-integration-best-in-class-low-power-and-floating-point-performance-in-new-stellaris-arm-cortex-m4f-microcontrollers/8/3325).)

41. The DNE is one of three ARM processors within the disclosed cable modem. It is referred to as "ARM #3" in the specification and the figures. ('775 Patent, Fig 1; 4:48-49.)

3. The Structure of the CME

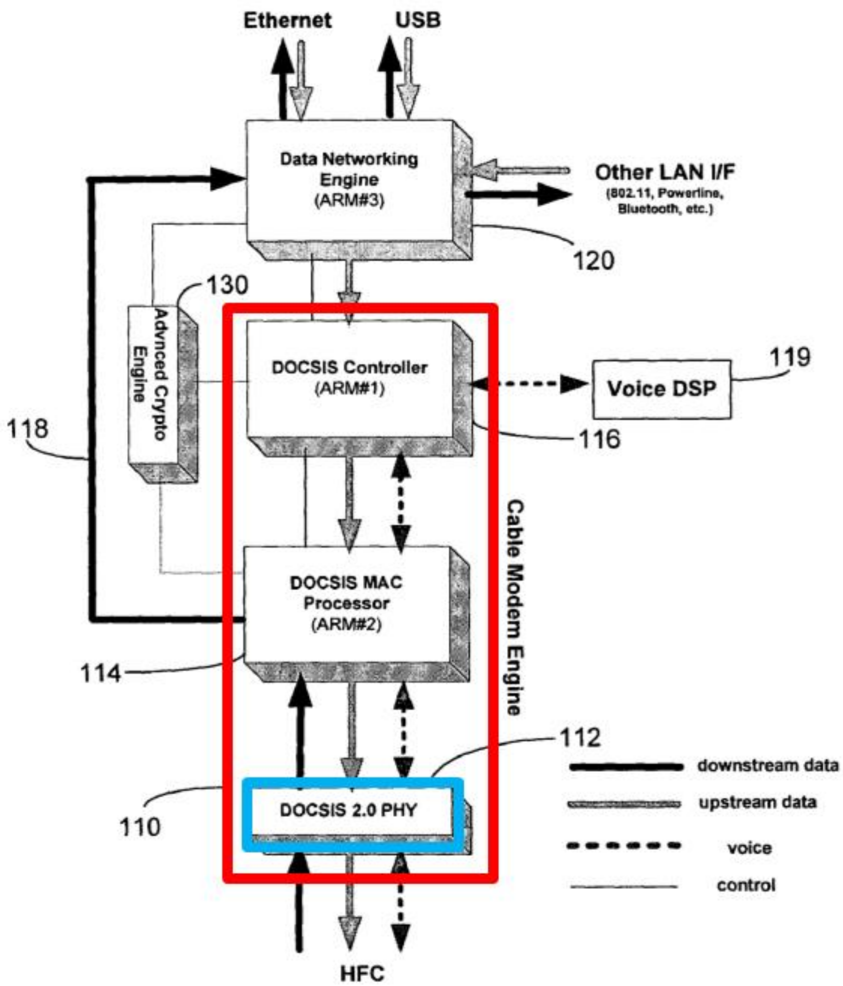
42. In contrast to the DNE, which is made up of only one ARM processor, the CME comprises multiple ARM processors and other discrete hardware components. In fact, another aspect of the alleged cable modem architecture invention is that the CME itself is partitioned into specific components:

> Another embodiment of the invention is a cable modem architecture. The architecture includes a cable modem engine having a DOCSIS PHY layer with a hardware transmitter and receiver, a DOCSIS MAC processor that implements real-time critical MAC functions for both upstream and downstream communications, and a DOCSIS controller implementing VoIP functionality. (*Id.*, 2:5-11.)

43. The DOCSIS PHY layer includes a "hardware transmitter and receiver." (*Id.*, 2:7-8; 2:58-59.) As explained in the specification, this DOCSIS PHY layer hardware "receives downstream data, transmits upstream data and receives and transmits voice data from/to an external source. In one implementation, the external source is a HFC (hybrid fiber coax) cable employing both fiber optic and coaxial cable as an effective means for delivering combined data, video, voice, CATV and other communications." (*Id.*, 2:61-67.)

44. I have annotated Figure 1 of the '775 Patent below to indicate the DOCSIS PHY

layer in blue and the CME in red:

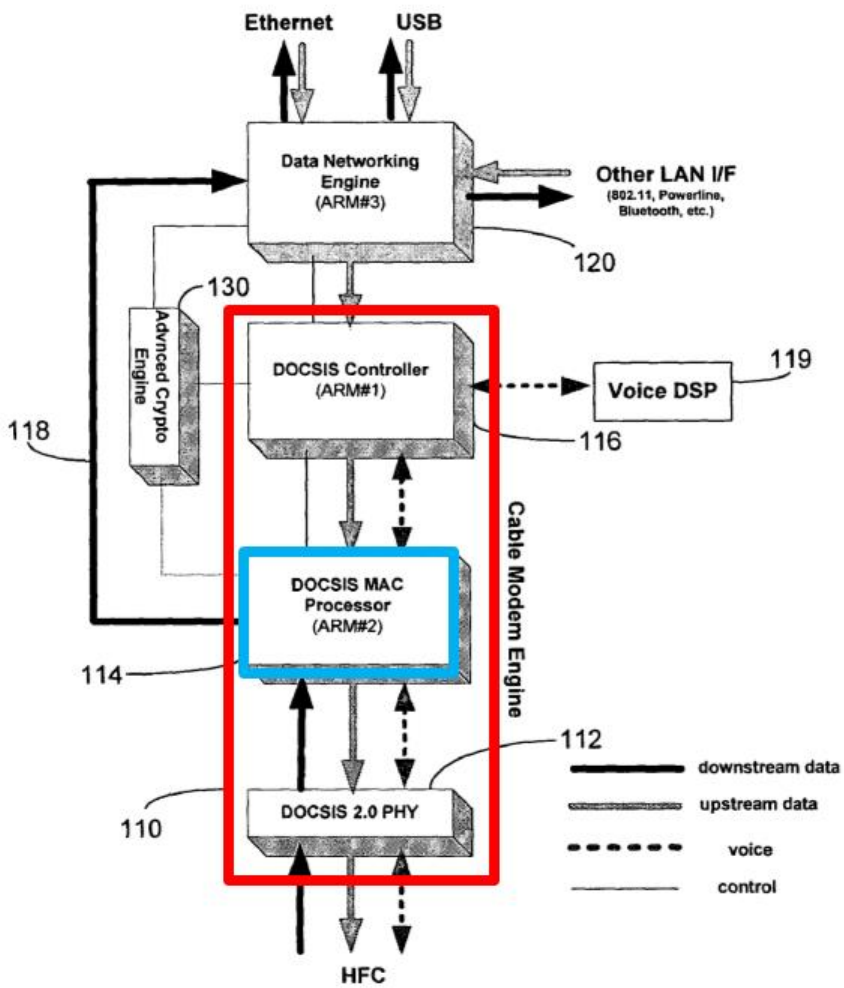


45. The CME also contains what is referred to in the specification as a "DOCSIS MAC processor." The term "DOCSIS MAC processor" does not have a plain and ordinary meaning in the art. A POSITA would know to rely on the specification's description of the "DOCSIS MAC processor" to understand what it is.

46. The acronym "MAC" standing alone, however, does have a plain meaning in the art. It stands for "Medium Access Control." MAC functions relate to accessing a shared physical transmission medium by network-attached devices. (Appx. B, at 432.)

47. In the '775 Patent, the DOCSIS MAC processor is implemented as another one of

the three ARM processors within the cable modem ('775 Patent, Fig 1; 3:17-18.) It is referred to as "ARM #2" in the specification and the figures. (*Id.*, Fig 1; 4:47.) I have annotated Figure 1 of the '775 Patent below to indicate the DOCSIS MAC processor in blue and the CME in red:

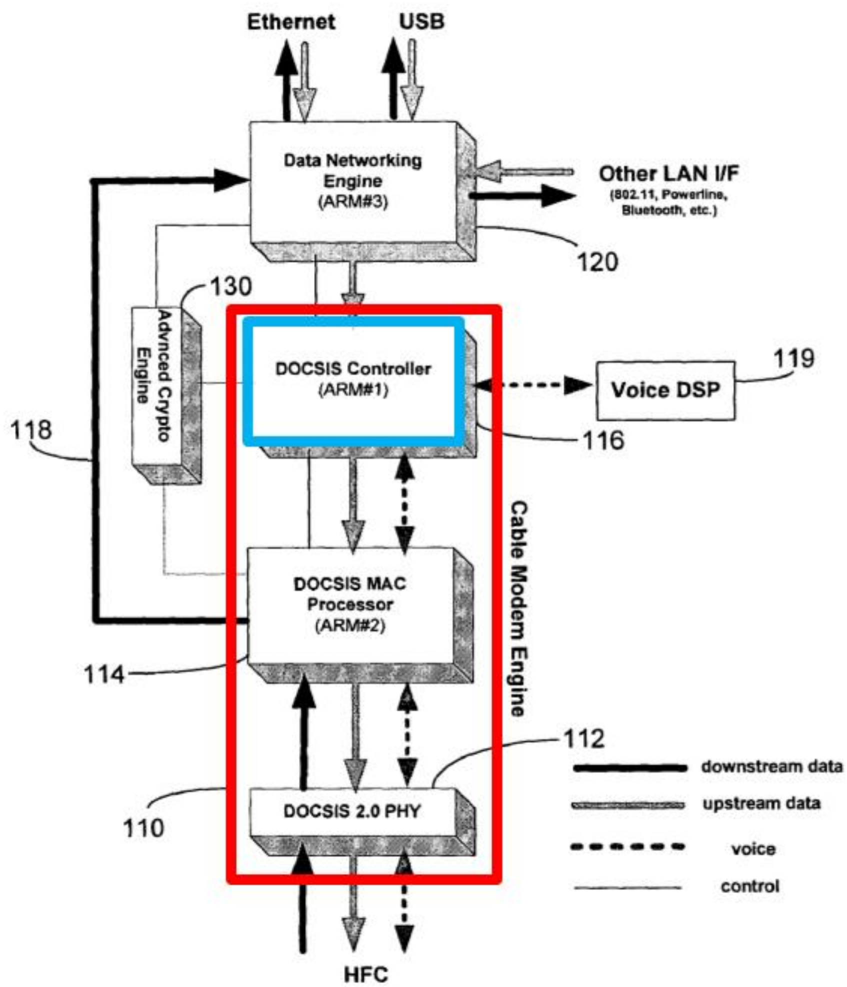


48. The DOCSIS MAC processor is described as performing a number of MAC functions. "These functions include US and DS synchronization, DS MAC address filtering, DS protocol filtering, US and DS PHS, concatenation, fragmentation, MAP processing, US transmission scheduling, as well as DOCSIS link-layer DES encryption and decryption." (*Id.*, 3:1-7.) Notwithstanding the name of the deice, the DOCSIS MAC processor does not perform all of the MAC functions of the cable modem. As I explain below, according to the specification, the "DOCSIS

controller" also performs MAC functions.

49. The CME also contains what is referred to in the specification as a "DOCSIS controller." The term "DOCSIS controller" does not have a plain and ordinary meaning in the art. A POSITA would know to rely on the specification's description of the "DOCSIS controller" to understand what it is.

50. In the '775 Patent, the DOCSIS controller is implemented as another one of the three ARM processors within the cable modem (*Id.*, Fig 1; 3:25.). It is referred to as "ARM #1" in the specification and the figures. (*Id.*, Fig 1; 4:47-48.) I have annotated Figure 1 of the '775 Patent below to indicate the DOCSIS controller in blue and the CME in red:

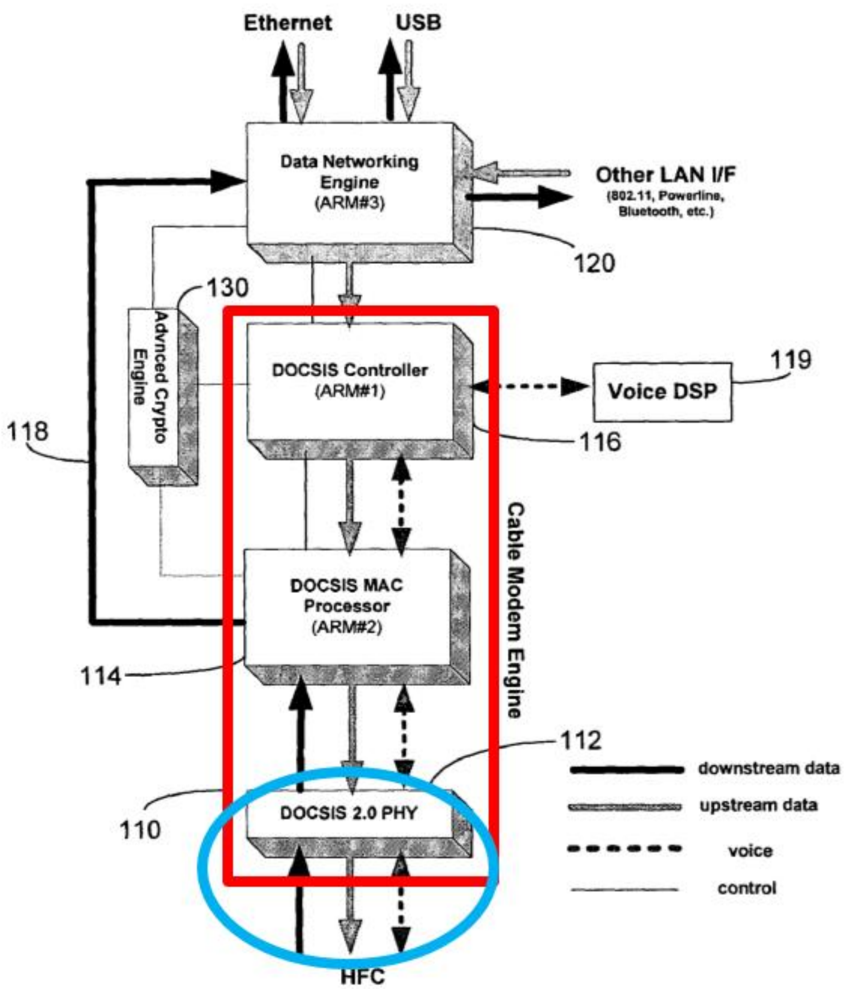


51. The DOCSIS controller performs all VoIP/PacketCable functionality. (*Id.*, 2:6-19, 3:39-48.) It also performs a number of other functions. (*Id.*, 3:21-38.) As I mentioned above, the DOCSIS controller performs a number of MAC functions, such as "MAC management message (MMM) processing" (*id.*, 3:27-29), "MAC address learning" (*id.*, 3:30), and "voice MAC driver" functions (*id.*, 3:46).

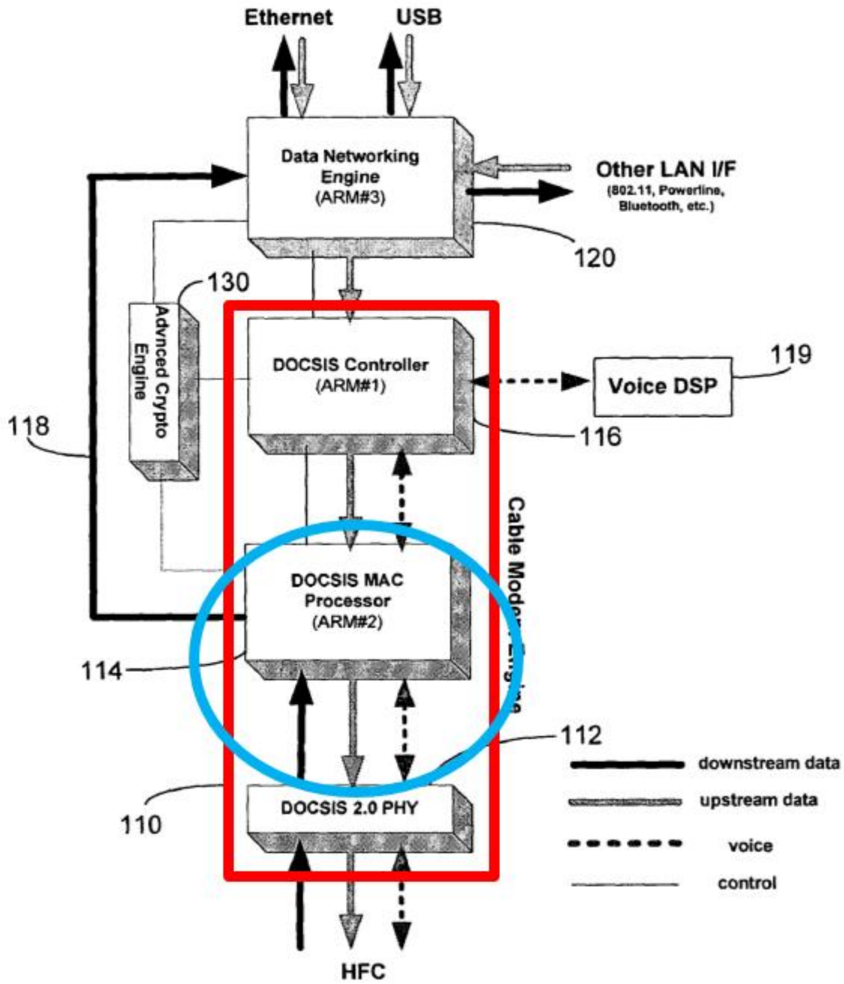
4. Data Flow Within the CME

52. As depicted in Figure 1 of the '775 Patent, the cable modem transmits upstream data (represented by a solid grey arrow), receives downstream data (represented by a solid black arrow), and transmits and receives voice data (represented by a dashed two-way arrow). (*Id.*, 2:61-63; Fig 1.)

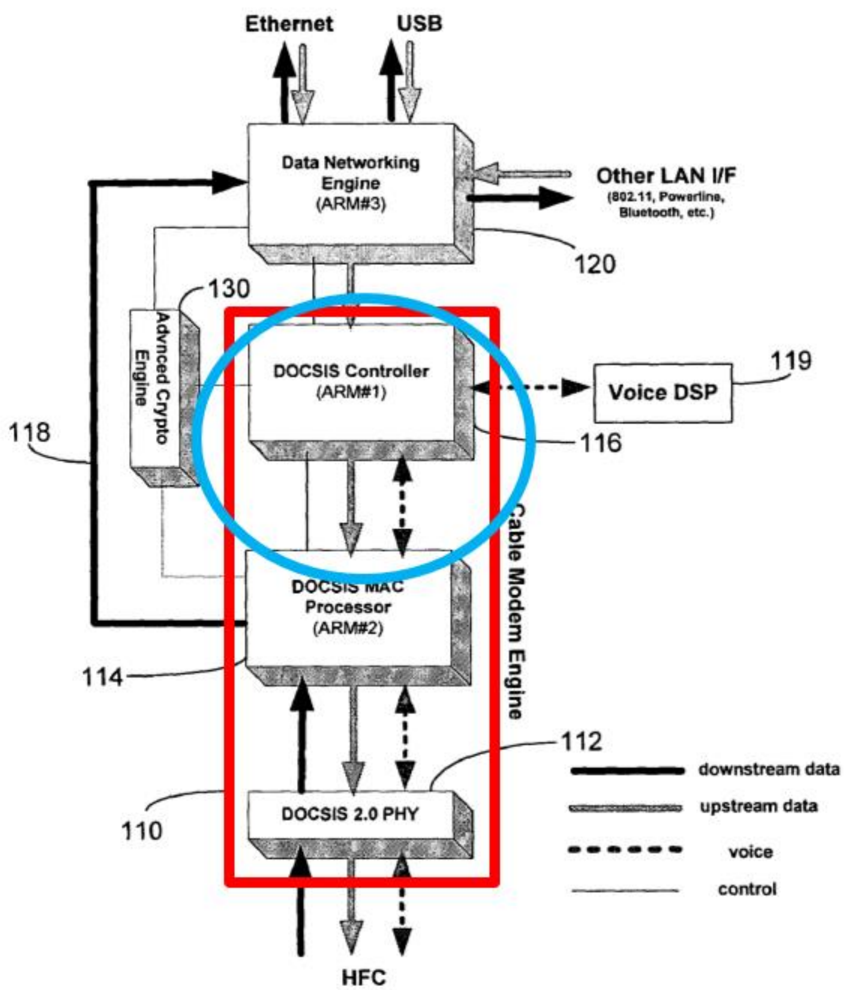
"Downstream" data is data a cable modem receives and is referred to in the specification as "DS PDU packets." (*Id.*, Fig 1; 2:61-63; 3:7-9; 3:11-17; 3:22-24; 4:49-53.) "Upstream" data is data the cable modem transmits and is referred to in the specification as "US PDU packets." (*Id.*, Fig 1; 2:61-63; 3:7-11; 3:21-22.) All upstream and downstream data and all voice data goes through the DOCSIS PHY layer hardware. (*Id.*, 2:61-67.) I have annotated Figure 1 of the '775 Patent in blue below to indicate where this is shown in the figure:



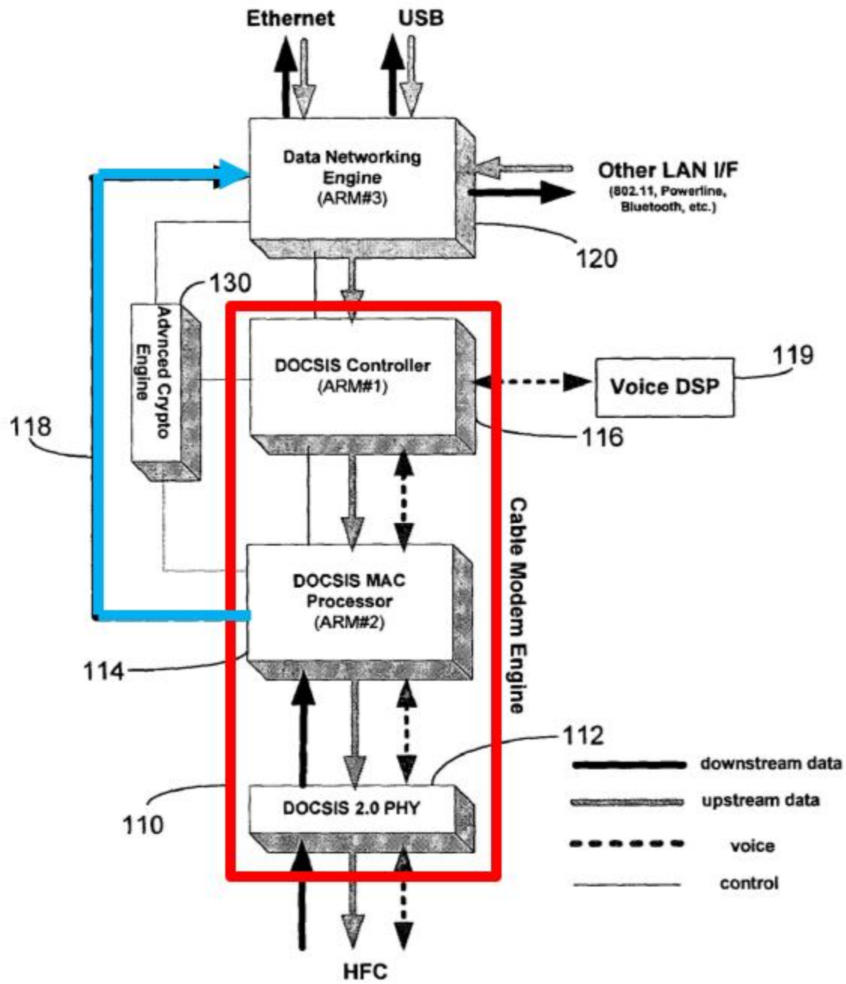
53. Similarly, all upstream and downstream data and all voice data goes through the DOCSIS MAC processor (*Id.*, 3:7-10.) I have annotated Figure 1 of the '775 Patent in blue below to indicate where this is shown in the figure:



54. In contrast, however, while all upstream and downstream voice data goes though the DOCSIS controller, only upstream data goes through the DOCSIS controller. (*Id.*, 3:9-11.) I have annotated Figure 1 of the '775 Patent in blue below to indicate where this is shown in the figure:



55. Downstream data bypasses the DOCSIS controller entirely and is sent by the DOCSIS MAC processor directly to the DNE. I have annotated Figure 1 of the ’775 Patent in blue below to indicate where this is shown in the figure:



56. The reason the DOCSIS MAC processor sends all downstream data directly to the DNE – bypassing the DOCSIS controller – is described in the specification as follows:

> To increase downstream throughput, all processing of DS PDU (protocol data unit) packets is done within processor **114** without involving controller **116**. After being processed, DS PDU packets are forwarded by processor **116** directly to data networking engine **120** along path **118**, bypassing controller **116**. (*Id.*, 3:11-16)
>
> To further boost downstream throughput, the downstream PDU packets are directly forwarded from the DOCSIS MAC processor **114** to the data networking engine **120** without going through DOCSIS controller **116**. This is made possible by exploiting the asymmetric nature of the DOCSIS US/DS **152** and **154**. (*Id.*, 4:49-55)

B. The Prosecution History of the ’775 Patent

57. During prosecution of the ’775 Patent, the examiner rejected the claims over US Published Application U.S. 2001/0039600 to Brooks et al. (“Brooks,” Appx. F). As relevant to my declaration, the examiner found that Brooks teaches the claim limitation “the cable modem functions performed by the cable modem engine are completely partitioned from the home networking functions performed by the data networking engine.” (Appx. G, Excepts of Prosecution History of the ’775 Patent, 2/5/10 Office Action at 4, 8.) This limitation appears in claim 18 of the ’775 Patent as issued. (’775 Patent, 8:24-27.)

58. In attempting to overcome the rejection, the applicants argued as follows:

> [T]he Office Action make the conclusion statement [sic] that “the data networking engine and cable modem engines are represented in Figures 1 and 2 of the [Brooks] reference…” However, Applicant is uncertain how any reasonable interpretation of these Figures can provide correspondence. For example, *Figure 2 of [Brooks] discloses only two processors, each of which, therefore, must correspond to the claimed data-networking and cable-modem engines.* However, the discussion of Figure 2 makes clear that the cable modem functions are performed by CMAC unit 224 *(see, e.g.,* paragraph 0042). Therefore, in order for the cable modem engine to contain a processor and perform the CMAC functions as claimed, *the cited cable modem engine must include circuitry to connect the processors with the CMAC unit. Because available connecting circuitry would be shared with the other processor, Applicant is uncertain how the asserted cable modem engine and home networking engine can be completely partitioned as claimed*.

(Appx. G, 4/5/10 Request to Withdraw Finality and Response to Final Office Action, at 6-7 (emphasis mine).) Thus, because the processor the examiner designated as the CME “shared” “connecting circuitry” with the processor the examiner designated as the DNE, the applicants argued the CME and DNE were not “completely partitioned.”

59. Initially, the examiner was not persuaded by this argument and repeated his rejection of the claims. In so doing, he confirmed his view that one of Brooks’ disclosed processors is the DNE and the other is the CME:

> *The first processor* processes information flowing to and from cable media interface circuitry. This *constitutes the data networking engine*, which performs the interacting with equipment, as claimed. *The second processor* performs the management of some message processing and scheduling, which constitutes cable modem functions other than those of the data networking engine (please see paragraph 0026). This then *constitutes the cable modem engine*, as claimed.

(Appx. G., 5/11/10 Advisory Action at 2 (emphasis mine).)

60. In response, the applicants started by reaffirming the argument they had previously made that if two processors share the same "connecting circuity" they cannot be completely partitioned:

> [I]t was pointed out that in Brooks '600, only two processors were disclosed. Therefore, from the Examiner's position that "the data networking engine and cable modem engines are represented in figures 1 and 2" (Office Action, p. 8), *it would follow that one of the two processors corresponded to the networking engine, and the other of the two processors corresponded to the cable modem engine.* It was further pointed out that while the discussion concerning Figure 2 in Brooks '600 paragraph 0042 makes clear that cable modem functions are performed by CMAC unit 224, if the cable modem engine is to contain a processor and perform CMAC functions as claimed, the cited cable modem engine must include circuitry to connect one of the processors with the CMAC unit. *It was noted, however, that because available connecting circuitry would be shared by both the one processor and the other processor, the asserted cable modem engine and home networking engine could not be completely partitioned as claimed.*

(Appx. G, 6/7/10 Amendment at 6-7 (emphasis mine).)

61. The applicants then argued further that Brooks' disclosure "does not square with the claim 1 feature that 'the cable modem functions performed by the cable modem engine are completely partitioned from the home networking functions performed by the data networking engine"

> because the CMAC/CPHY block (114, 118, 224 and 228) communicates with both the processors 102 and 104 *by sharing the same data paths and sharing the same direct memory access controller*. (See peripheral bus 112 - bridge 110 - system bus 108 in Fig. 1 and APB 214- DMA Controller/ASB-APB Bridge 212-ASB 210 in Fig. 2, and paragraphs 0034 and 0035).

(*Id.* at 8.)

62. Figure 2 of Brooks is reproduced below. I have annotated the figure to indicate in red the two processors relied on by the examiner as the CME and DNE. The "CMAC/CPHY block" is indicated in blue. The "connecting circuitry" which is "shared" by the two processors is highlighted in yellow. The shared DMA controller is highlighted in green.

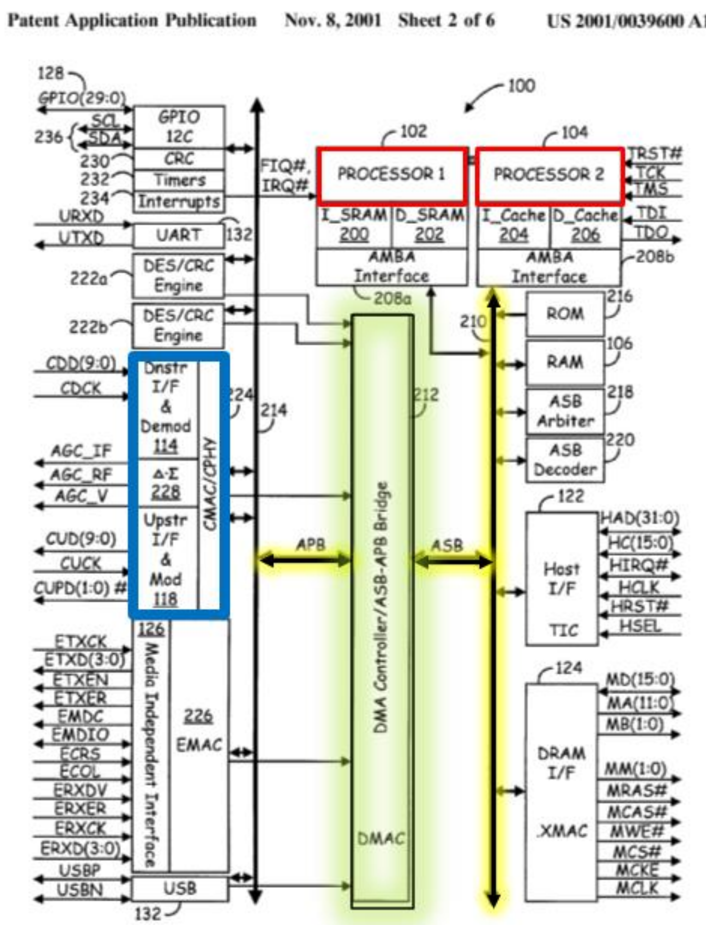


Fig. 2

I note that a DMA controller is a device which controls access to memory devices. (Appx. H, Excerpted The Authoritative Dictionary of IEEE Standards Terms (7th Ed. 2000), at 317-318 (definitions of "direct memory access" and "direct memory access controller").)

63. After the applicant made these arguments, the examiner dropped his rejection of the claims in view of the Brooks reference. (Appx. G, 9/2/11 Office Action.)

C. Claim 18 of the '775 Patent

64. Claim 18 of the '775 Patent requires "a data networking engine *implemented in a first circuit* that includes at least one processor" and "a cable modem engine *implemented in a second circuit* that includes at least one processor, *the second circuit being separate from the first circuit*." ('775 Patent, 7:34-35; 8:5-7 (emphasis mine).) The specification does not explain in what sense the word "circuit" is used in the claim. In fact, the specification does not contain the word "circuit" at all.

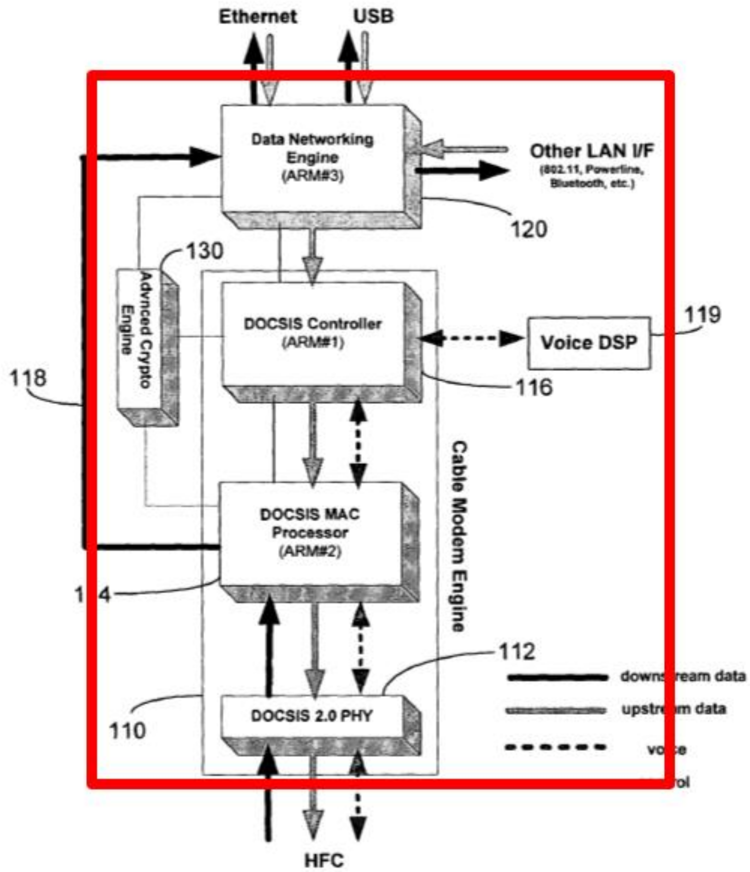
65. In the context of computer-related systems, a single "circuit" can mean anything from a basic simple electrical path or single transistor, to all of the devices on a single circuit board, to all of the circuit board(s) in a computer or computerized device. Standard definitions of "circuit" reflect this ambiguity. For example, the Microsoft Computer Dictionary, 5th Edition (2002), p. 99, defines "circuit" as:

> 1. Any path that can carry electrical current. 2. A combination of electrical components interconnected to perform a particular task. At one level, a computer consists of a single circuit; at another, it consists of hundreds of interconnected circuits.

(Appx. C, at 99.)

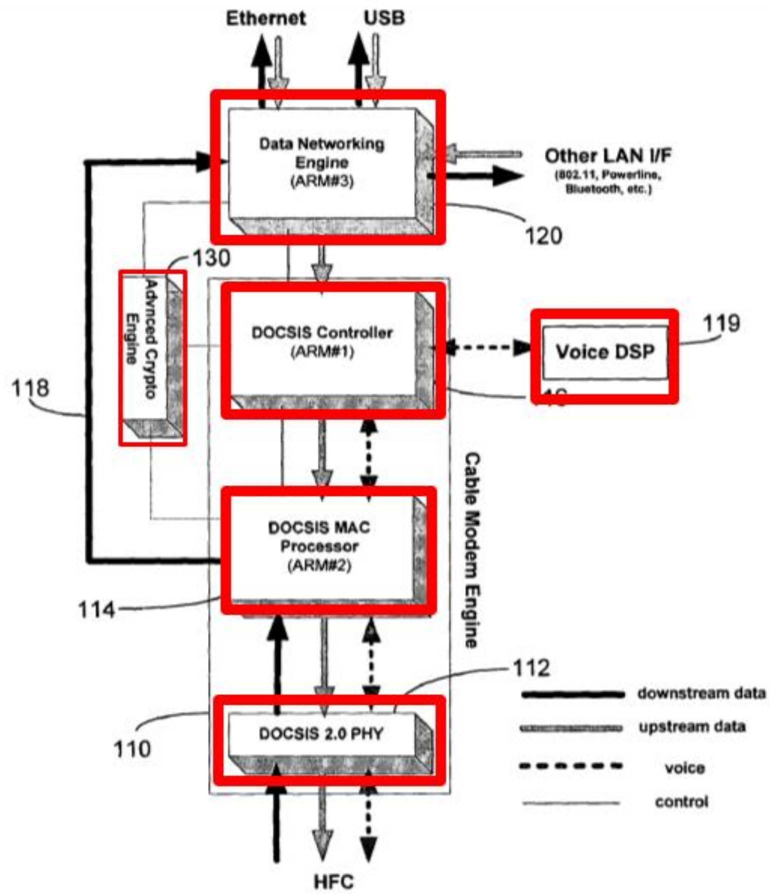
66. As a result, it is impossible to know how many circuits a device contains, or what those circuits are, unless one knows what meaning of the word "circuit" is being employed. This can be demonstrated with reference to Figure 1 of the '775 Patent. If one were to ask how many circuits it depicts or what the boundaries are of those circuits, there would be no way to answer without knowing what meaning of the word "circuit" to apply.

67. For example, Figure 1 of the '775 Patent depicts a cable modem. Thus, all of Figure 1 – the entire cable modem – can be deemed a single circuit ("at one level, a computer consists of a single circuit"). I annotate Figure 1 below by showing this single "circuit" in red:



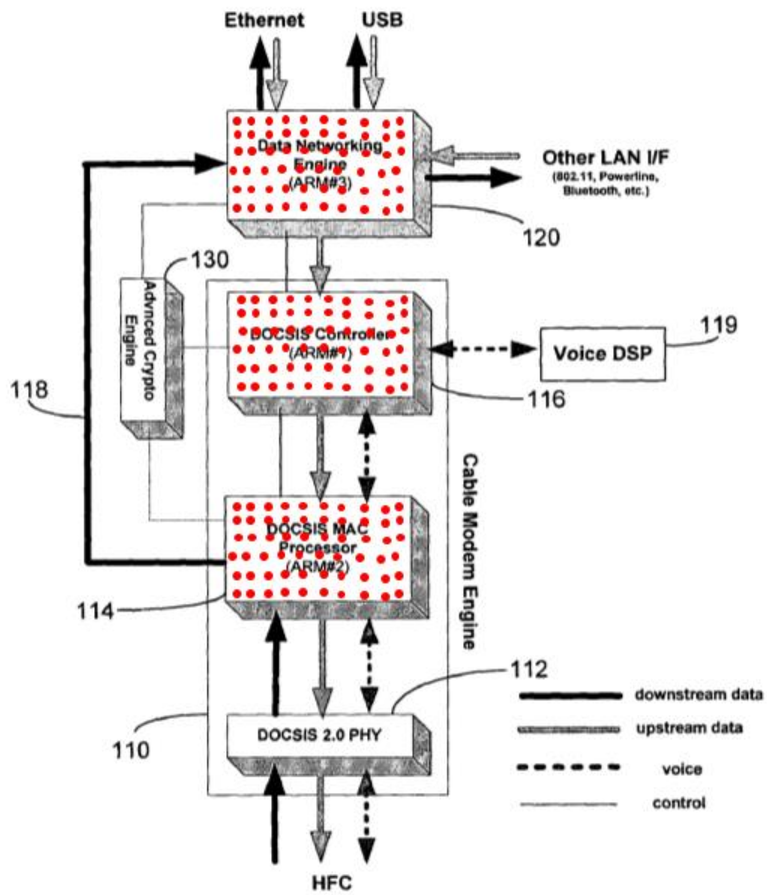
68. Applying this meaning of "circuit," the cable modem disclosed in the '775 Patent contains only one circuit. The claim 18 requirement that a cable modem contain a "first circuit" and a "second circuit" would not be satisfied.

69. On the other hand, Figure 1 shows a number of discrete devices, each of which is responsible for its own specialized tasks. As such, each of ARM #1 (the "DOCSIS controller"), ARM # 2 (the "DOCSIS MAC processor"), ARM # 3 (the "Data Networking Engine"), the DOCSIS 2.0 PHY hardware, the Voice DSP (Digital Signal Processor) and the "Advanced Crypto Engine" can each be considered a separate "circuit," as each is a discrete piece of hardware made up of electrical components for performing their designated tasks. I indicate each of these different "circuits" in red below:



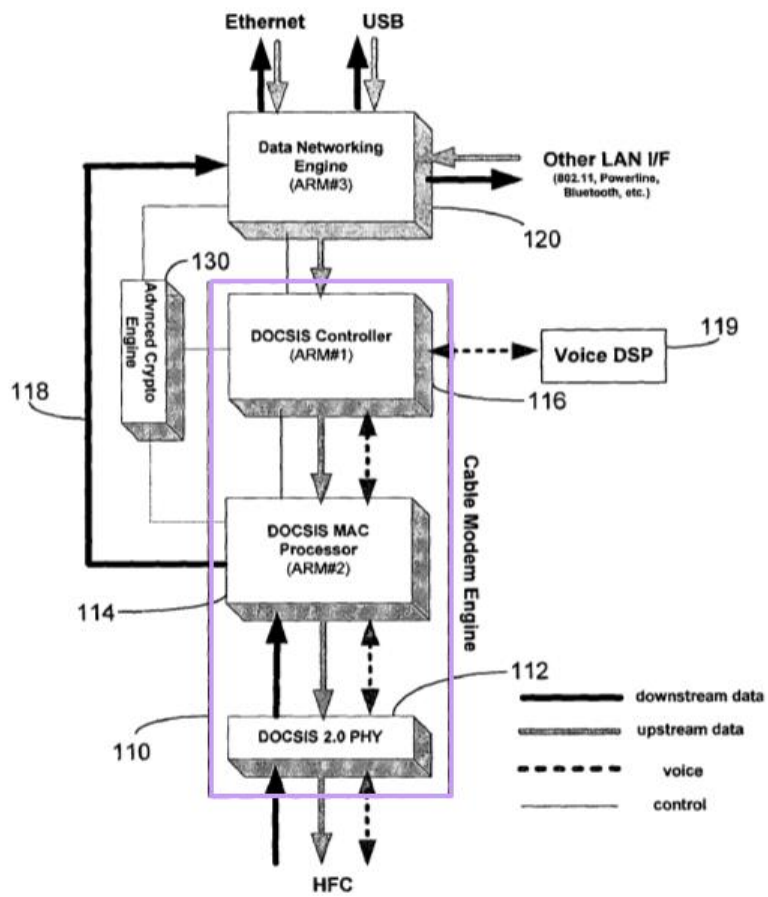
70. Applying this meaning of "circuit," the disclosed "cable modem engine" is implemented in at least three different circuits – the ARM #1 "circuit," the ARM # 2 "circuit" and the DOCSIS 2.0 PHY "circuit." The claim 18 requirement that the cable modem engine be implemented "in a second circuit" would not be satisfied.

71. Then again, each of the different devices identified in Paragraph 67 above are themselves made up of many electrical devices. For example, each of ARM #1, ARM #2 and ARM # 3 is made up of billions of transistors and electrical paths. Using that definition of "circuit," each of these ARMs is literally made up of billions of different circuits. I have attempted to depict this in my annotation of Figure 1 below, where each of these ARMs is made up of many different circuits represented by red dots:



72. Applying this meaning of "circuit," the disclosed "cable modem engine" is implemented in billions of different circuits, as is the disclosed "data networking engine." The claim 18 requirement that the data networking engine be implemented "in a first circuit" would not be satisfied. Nor would the claim 18 requirement that the cable modem engine be implemented "in a second circuit."

73. I note that Figure 1 depicts a box drawn around all of the components of the CME. I highlight this box in purple below:



74. The specification does not explain what this box is. If it is intended to refer to a circuit *board* on which all of the components of the CME are placed – meaning the DNE is not implemented on the same physical circuit board as the DNE – then under one meaning of "circuit" the DNE and the CME can be deemed to be implemented in a first circuit and a second circuit, respectively (the "first circuit" and "second circuit" would be separate circuit boards). If the DNE and CME are not implemented on different physical circuit boards, however, there is no meaning of "circuit" pursuant to which the disclosed DNE is "implemented in a first circuit" and the disclosed CME is "implemented in a second circuit."

75. Because the specification does not explain which of the mutually-exclusive meanings of "circuit" to apply to claim 18, the scope of the claim is indefinite. There is no way to tell whether any particular device is made up of only one circuit, of two circuits or of billions of

circuits. Indeed, as demonstrated above, there is no way tell even if the disclosed cable modem embodiment satisfies claim 18.

76. Claim 18 also requires that the claimed cable modem engine include both a "DOCSIS MAC processor" and a "DOCSIS controller." As I explained in paragraphs 45 and 49 above, these terms do not have a plain and ordinary meaning in the art, and a POSITA would understand that, in the context of '775 Patent, these terms refer to the DOCSIS MAC processor described in the specification (*see, e.g.*, '775 Patent, 3:1-20; 4:41-57; Figures 1 & 2) and the DOCSIS controller described in the specification (*see, e.g.*, *id.*, 3:21-48; 4:41-57; Figures 1 & 2). Otherwise, the claim is indefinite for the additional reason that there would be no way to know what "DOCSIS MAC processor" and "DOCSIS controller" mean, or whether an accused cable modem contains one or both of these devices.

77. To understand the scope of claim 18, it is important to understand not just what a "DOCSIS MAC processor" is and what a "DOCSIS controller" is, but also what their boundaries are. This is because the claim requires that "the DOCSIS MAC processor [be] configured to process downstream PDU packets and forward the processed packets directly to the data networking engine without the involvement of the DOCSIS controller in order to boost downstream throughput" *(Id.*, 8:18-22.) This is the aspect of the alleged invention I explained in paragraphs 54-56 above, whereby downstream data is sent directly to the DNE by the DOCSIS MAC processor, bypassing the DOCSIS controller. Unless one understands where the DOCSIS MAC processor ends and the DOCSIS controller begins, one would not be able to ascertain whether an accused cable modem has a "DOCSIS MAC processor" which processes downstream packets "without the involvement of the DOCSIS controller."

78. Claim 18 is also indefinite because it requires "a cable modem engine … *that*

includes at least one processor." ('775 Patent, 8:5-6 (emphasis mine).) My understanding is that this would cover a cable modem engine that includes only one processor. However, the claim also expressly requires that the cable modem engine contain a DOCSIS MAC processor and a DOCSIS controller, both of which (as I explain in paragraphs 47 and 50 above) are ARM processors. Thus, the claim is indefinite for the additional reason that the claim covers cable modem engines that contain only one processor, but that would be impossible in view of the requirement that the claim also requires that the CME contain both a DOCSIS MAC processor and a DOCSIS controller.

79. Finally, claim 18 requires a "data bus that connects the data networking engine to the cable modem engine, wherein the cable modem functions performed by the cable modem engine are completely partitioned from the home networking functions performed by the data networking engine." (*Id.*, 8:23-27.) This limitation renders the claim indefinite, as the "wherein" clause is incompatible with the requirement that a data bus connect the DNE and CME. As explained in paragraphs 57-63 above, the applicant successfully argued that a DNE and CME are not "completely partitioned" if they share "connecting circuitry" or "data paths." The "data bus" as claimed would be shared "connecting circuitry" and a shared "data path."

VI. THE '690 PATENT

A. The Disclosure of the '690 Patent

80. The '690 Patent is titled "Receiver Determined Probe." According to the specification, in the prior art, probes having a predefined form would be sent "between nodes of the network in order to allow a receiving node on the network to determine some of the characteristics of the channel between the receiving node and the transmitting node." ('690 Patent, 1:48-53.) "By comparing the reference probe with the actual received probe, the receiver can determine some of the characteristics of the channel between the transmitting and receiving node." (*Id.*, 1:54-57.)

81. The problem with the prior art, according to the specification, is the fact that the

probes have a predetermined form. "[R]equiring the transmitting node to send a predetermined probe reduces the amount flexibility …. Nonetheless, this reduction in the flexibility must be suffered because it is critical to the process that the receiving node knows the precise form of the transmitted probe." (*Id.*, 1:57-62.)

82. The purported solution to this problem, as the title of the patent suggests, is a "receiver determined probe." The probes do not have a predefined form. Instead, the receiver of the probe determines the form of the probe that it wants to receive. The receiving node sends a "probe request" to a transmitting node which contains "parameters" that define the form of the probe the receiving node wants to receive. The transmitter of the probe then generates the probe according to those parameters. As such, the probe that is generated by the transmitting node "will have a form dictated by the parameters specified in the probe request." (*Id.*, 1:66-2:19.)

B. Claims 1 and 9 of the '690 Patent

83. Unlike the disclosure of the '690 Patent, wherein the receiving node (which can also be referred to as the "requesting node" since it sends the probe request) sends the parameters used to generate the probe, claims 1 and 9 of the '690 Patent require that both the requesting node and the transmitting node separately determine a "plurality of parameters associated with the generation" of the probe. (*Id.*, 13:46-48; 13:51-52; 14:19-21; 14:26-28.) Both claims also require that the probe actually be generated "in accordance with" both the plurality of parameters sent by the requesting node (the "first plurality of parameters") and the plurality of parameters determined by the transmitting node (the "second plurality of parameters"). (*Id.*, 13:53-54; 14:25-28).

84. However, claim 1 requires that the form of the probe be "dictated by the first plurality of parameters" (*Id.*, 13:55-56.) Similarly, claim 9 requires that the "first plurality of probe parameters compris[e] a form for the probe." (claim 9, *Id.*, 14:21-23.) Neither requirement makes any mention of the second plurality of parameters. From this language, the claims appear to cover the form of the

probe being determined only by the parameters sent by the requesting node. This renders the claim indefinite. By definition, "parameters" define the form of the probe that will be generated. (*Id.*, 2:6.) If the "first plurality of parameters" alone determine the form of the probe, then the probe cannot be generated "in accordance with" the second plurality of parameters as required by this other limitation in the claims.

VII. THE '682 PATENT

A. The Disclosure of the '682 Patent

85. The '682 Patent is titled "Method And System For Service Group Management In A Cable Network." Pursuant to disclosed embodiments, a CMTS assigns each cable modem to a service group based on the cable modem's signal to noise ratio ("SNR") profile. The CMTS then uses a "composite worst-case SNR profile" for each service group to determine how it will communicate with the cable modems in each service group respectively. I will explain this below.

86. A SNR is the ratio of the signal level to the noise level. The higher the SNR the greater the ratio of signal to noise. Greater signal and less noise is better, as noise interferes with the ability to understand or properly interpret the signal that is received. (Appx. I, Excerpted Newton's Telecom Dictionary (20th Ed. 2004), at 747.)

87. An "SNR over a range of frequencies" is an "SNR profile." ('682 Patent, 3:57-58.) Each band of frequencies for which the SNR is measured is referred to as a "subcarrier" or "channel." (*Id.*, 4:7-8.) Thus, line 222 in Fig 2B of the '682 Patent (reproduced below) can be the SNR profile of a single cable modem over the range of frequencies from subcarrier 1 ("sub1") to subcarrier 8 ("sub8") (*Id.*, 4:7-8; 4:11-13.) I have included explanatory annotations to the figure in which I assume that line 222 is the SNR profile for a hypothetical cable modem "A" ("CM[A]"). Each step in line 222 is the SNR of CM[A] at one of the subcarriers:

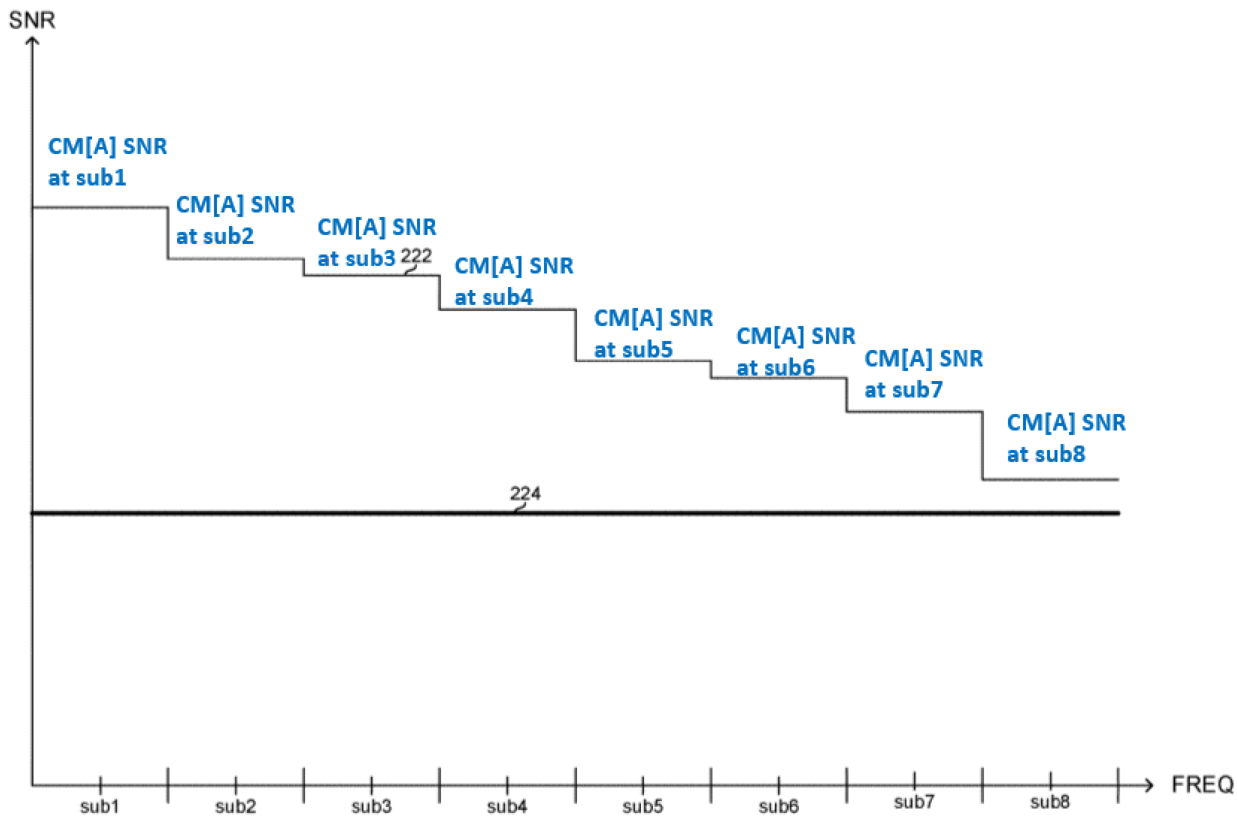


FIG. 2B

88. Each cable modem determines its own SNR profile (*id.*, 5:34-35) and sends that SNR profile to the CMTS. (*Id.*, 5:36-37; Figure 3A step 304.) Pursuant to disclosed embodiments, a CMTS assigns each cable modem to a service group based on the cable modem's SNR profile. (*Id.*, 5:37-39; Figure 3A step 306.)

89. The CMTS then uses a so-called "composite worst-case SNR profile" for each service group to determine how it will communicate with the cable modems in that service group. (*Id.*, 4:9-11; 5:7-12; 5:40-41.) The "composite worst-case SNR profile" for a service group is "the worst case SNR for [each] subcarrier among the CMs in that particular service group." (*Id.*, 5:42-46.)

90. Thus, if there are 5 cable modems (CM[A] - CM[E]) in a hypothetical service group, the "composite worst-case SNR profile" for that service group reflects the worst SNR of all the cable modems in the service group for each subcarrier. I annotate Fig 2B of the '682 Patent to demonstrate

this example. In this example, CM[A] has the worst SNR at subcarriers 2, 5 and 7, CM[B] has the worst SNR at subcarrier 1, CM[C] has the worst SNR at subcarrier 6, CM[D] has the worst SNR at subcarriers 3 and 8, and CM[E] has the worst SNR at subcarrier 4:

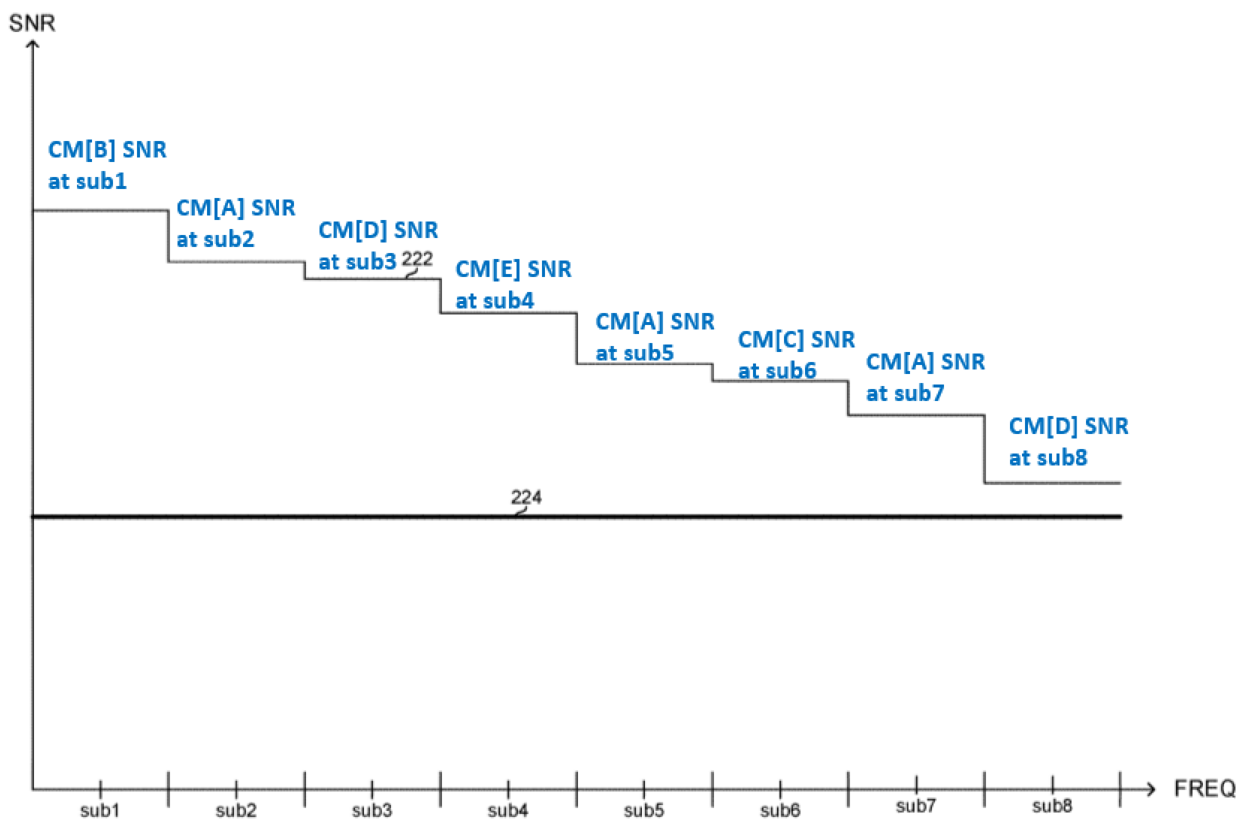


FIG. 2B

91. The need for such a "composite worst-case SNR profile" for each service group stems from the fact that "physical layer communication parameters are determined per service group and per channel/subcarrier." (*Id.*, 5:40-41). In other words, if communication parameters for a subcarrier are selected to accommodate the cable modem having the worst case SNR in the service group, all other CMs in the service group (having better SNRs) will be able to accommodate those communication parameters as well.

92. I note that the phrase "composite worst-case SNR profile" does not have a plain and

ordinary meaning in the art.

B. Claim 1 of the'682 Patent

93. Claim 1 of the '682 Patent does not recite a "composite worst-case SNR profile" for the cable modems in a service group. Instead, it requires generating "a composite SNR-related metric based at least in part on a worst-case SNR profile…" for the cable modems in a service group (*Id.*, 8:12-15.) In other words, a "composite SNR-related metric" is generated from a "worst-case SNR profile," such that the former is in some way "based at least in part on" the latter. As I will explain, this renders the claim indefinite because the "composite SNR-related metric" and the "worst-case SNR profile" must both refer to the disclosed "composite worst-case SNR profile" described in paragraphs 89-92 above.

94. "Worst-case SNR profile" does not have a plain and ordinary meaning in the art. Since the "worst case" SNR is always an SNR of 0, a POSITA seeing the term "worst-case SNR profile" would most likely assume it is an SNR "profile" containing only 0s. In this event, the claim phrase "worst-case SNR profile of said SNR-related metrics…" would be unintelligible. Thus, a POSITA would look to the specification for a meaning of "worst-case SNR profile." As I explain in paragraph 89 above, the specification explains that a "*composite* worst-case SNR profile" for a service group is "the worst case SNR for [each] subcarrier among the CMs in that particular service group." As such, a POSITA would interpret "worst-case SNR profile" as referring to the "composite worst-case SNR profile" described in the specification. Otherwise, the claim is indefinite for the additional reason that there is no way to tell what a "worst-case SNR profile" is.

95. The phrase "composite SNR-related metric" does not have a plain and ordinary meaning in the art and is not used in the specification. However, the specification teaches that an example of a "composite metric" would be a "composite SNR profile." (4:47-49) In view of the

specification, then, a POSITA would understand the claimed "composite *SNR-related* metric" to refer to that "composite SNR profile." And in the specification, the phrase "composite SNR profile" is used as shorthand for "composite worst-case SNR profile" (see e.g. 5:40-6:6 and Fig. 3A; a composite worst case SNR profile is used (5:4-46), which is synonymously referred to as a "composite SNR profile" (Fig. 3A step 308)). Thus, the only meaning a POSITA could ascribe to the claim phrase "composite SNR-related metric" is "composite worst-case SNR profile." Otherwise, the claim is indefinite for the additional reason that there is no way to tell what a "composite SNR-related metric" is.

96. Because "composite SNR-related metric" and "worst-case SNR profile" must both refer to the "composite worst-case SNR profile," however, the claim is indefinite. There is no way to know how the "composite SNR-related metric" can be "based *at least in part on*" the "worst-case SNR profile" since the two refer to the same thing.

97. In addition, although the claimed cable modems are assigned "among a plurality of service groups" (*id.*, 8:7-8), the claim then requires that a number of steps be performed with respect to a particular "said one of said plurality of service groups." (*Id.*, 8:18; 8:21-22.) There is no antecedent in the claim for "said one of said plurality of service groups," and there is no way to know which one service group among the "plurality of service groups" is being referred to. Claim 1 is therefore indefinite for this additional reason.

VIII. RESERVATION OF RIGHTS

98. I reserve the right to respond to any evidence (including expert opinions) that Plaintiff Entropic Communications, LLC may offer in support of its claim construction positions.

* * *

I declare under penalty of perjury that the foregoing is true and correct.

Dated: April 4, 2023

Kevin C Almeroth

Kevin C. Almeroth, Ph.D.

Appendix A

Kevin C. Almeroth

Professor Emeritus
Department of Computer Science
University of California
Santa Barbara, CA 93106-5110
(805)636-1123 (office)
(805)893-8553 (fax)
almeroth@cs.ucsb.edu (email)
http://www.cs.ucsb.edu/~almeroth (WWW URL)

Education

Ph.D.	June 1997	*Georgia Institute of Technology* Computer Science *Dissertation Title*: Networking and System Support for the Efficient, Scalable Delivery of Services in Interactive Multimedia Systems *Minor*: Telecommunications Public Policy
M.S.	June 1994	*Georgia Institute of Technology* Computer Science *Specialization*: Networking and Systems
B.S. **(high honors)**	June 1992	*Georgia Institute of Technology* Information and Computer Science *Minors*: Economics, Technical Communication, American Literature

Employment History

Professor Emeritus	Department of Computer Science University of California Santa Barbara, CA	Nov 2020 -- present
Professor	Department of Computer Science University of California Santa Barbara, CA	Jul 2005 -- Oct 2020
Associate Dean	College of Engineering University of California Santa Barbara, CA	Mar 2007 -- Aug 2009
Vice Chair	Department of Computer Science University of California Santa Barbara, CA	Jul 2000 -- Nov 2005

Associate Professor	Department of Computer Science University of California Santa Barbara, CA	Jul 2001 -- Jun 2005
Assistant Professor	Department of Computer Science University of California Santa Barbara, CA	Jul 1997 -- Jun 2001
Graduate Researcher	Broadband Telecommunications Center Georgia Center for Adv Telecom Tech Atlanta, GA	Sep 1996--Jun 1997
Graduate Intern	IBM T.J. Watson Research Labs Hawthorne, NY	Jun 1995--Sep 1995
Support Specialist	Office of Information Technology Georgia Institute of Technology Atlanta, GA	Sep 1995--Jun 1997
Research Assistant	College of Computing Georgia Institute of Technology Atlanta, GA	Jan 1994--Mar 1994
Graduate Intern	Hitachi Telecommunications Norcross, GA	Jun 1992--Sep 1992
Undergraduate Intern	IBM Research Triangle Park, NC	Jun 1989--Sep 1989 Jun 1990--Sep 1990 Mar 1991--Sep 1991

Industry Technical Advising

Board of Directors	The New Media Studio Santa Barbara, CA	Nov 2006 -- present
Co-Founder & Chairman of the Board	Santa Barbara Labs, LLC Santa Barbara, CA	Sep 2007 -- Dec 2009
Board of Advisors	Techknowledge Point Santa Barbara, CA	May 2001 -- Dec 2007
Technical Advisory Board	Occam Networks, Inc. Santa Barbara, CA	May 2000 -- Dec 2010
Board of Advisors	Airplay Inc. San Francisco, CA	Jun 2005 -- Aug 2009
Consultant	Lockheed Martin Corporation San Jose, CA	Nov 1999 -- Jun 2009

Board of Advisors	Santa Barbara Technology Group Santa Barbara, CA	Sep 2000 -- Dec 2004
Board of Directors	Virtual Bandwidth, Inc. Santa Barbara, CA	Nov 2000 -- Jun 2001
Board of Advisors & Affiliated Scientist	Digital Fountain San Francisco, CA	Jan 2000 -- Dec 2001
Senior Technologist	IP Multicast Initiative, Stardust Forums Campbell, CA	Jun 1998 -- Dec 2000

I. Teaching

A. Courses Taught

CS 176A	Intro to Computer Communication Networks	Fall 1997, Fall 1998, Fall 2002, Fall 2003, Fall 2004, Spring 2005, Spring 2006, Spring 2007, Spring 2008, Fall 2008, Fall 2009, Fall 2010, Fall 2011, Fall 2012, Fall 2013, Fall 2014, Spring 2017, Spring 2018, Spring 2020, Fall 2020
CS 176B	Network Computing	Winter 2000, Winter 2001, Winter 2002, Winter 2012, Winter 2014, Winter 2015, Winter 2018, Winter 2019, Winter 2020
MAT 201B	Media Networks and Services	Fall 1999, Fall 2000, Fall 2001, Fall 2003
CS 276	Distributed Computing and Computer Networks	Winter 1999, Spring 2000, Fall 2002, Fall 2005, Fall 2018
CS 290I	Networking for Multimedia Systems	Winter 1998, Spring 1999, Fall 2004, Winter 2010
CS 595N	Technology and Society	Winter 2005, Fall 2005, Spring 2006, Fall 2006, Spring 2007, Fall 2007, Spring 2008, Fall 2008, Spring 2009
CS 595N	Economic Systems Seminar	Winter 2004, Spring 2004, Winter 2005, Spring 2005
CS 595N	Networking Seminar	Winter 1999, Fall 1999, Winter 2003, Winter 2019
CS 595N	Wireless Networking & Multimedia Seminar	Fall 2000
CS 595I	Systems Design and Implementation Seminar	Fall 1999, Fall 2000, Winter 2001, Spring 2001, Winter 2002, Spring 2002

B. Other Teaching Experience

- *The Evolution of Advanced Networking Services: From the ARPAnet to Internet2*, Instructor, Summer 2001. Short course taught at Escuela de Ciencias Informatica (ECI) sponsored by the Universidad de

Buenos Aires.

- *Johns Hopkins Center for Talented Youth*, Instructor, Summer 1994. CTY is a program to teach gifted high school students the fundamentals of computer science.

- *Georgia Institute of Technology*, Graduate Teaching Assistant, Sep 1994--Sep 1996. Worked as a TA for 12 quarters teaching 7 different courses (4 undergraduate and 3 graduate).

C. Ph.D. Students Advised [14 graduated]

14. Daniel Havey
    Research Area: *Throughput and Delay on the Packet Switched Internet*
    Date Graduated: Winter 2015
    First Position: Microsoft
13. Lara Deek (co-advised with E. Belding)
    Research Area: *Resource-Efficient Wireless Systems for Emerging Wireless Networks*
    Date Graduated: Summer 2014
    First Position: Post Doc, UIUC
12. Mike Wittie
    Research Area: *Towards Sustained Scalability of Communication Networks*
    Date Graduated: Summer 2011
    First Position: Assistant Professor, Montana State University
11. Allan Knight
    Research Area: *Supporting Integration of Educational Technologies and Research of Their Effects on Learning*
    Date Graduated: Summer 2009
    First Position: Research Scientist, Citrix Online
10. Hangjin Zhang
    Research Area: *Towards Blended Learning: Educational Technology to Improve and Assess Teaching and Learning*
    Date Graduated: Spring 2009
    First Position: Microsoft
9. Gayatri Swamynathan
    Dissertation Title: *Towards Reliable Reputations for Distributed Applications*
    Date Graduated: Spring 2008
    First Position: Zynga
8. Amit Jardosh (co-advised with E. Belding)
    Dissertation Title: *Adaptive Large-Scale Wireles Networks: Measurements, Protocol Designs, and Simulation Studies*
    Date Graduated: Fall 2007
    First Position: Yahoo!
7. Khaled Harras
    Dissertation Title: *Protocol and Architectural Challenges in Delay and Disruption Tolerant Networks*
    Date Graduated: Summer 2007
    First Position: Assistant Professor, Carnegie Mellon University
6. Krishna Ramachandran (co-advised with E. Belding)
    Dissertation Title: *Design, Deployment, and Management of High-Capacity Wireless Mesh Networks*

Date Graduated: Winter 2006
First Position: Research Scientist, Citrix Online

5. Robert Chalmers
   Dissertation Title: *Improving Device Mobility with Intelligence at the Network Edge*
   Date Graduated: Summer 2004
   First Position: President and CEO, Limbo.net
4. Prashant Rajvaidya
   Dissertation Title: *Achieving Robust and Secure Deployment of Multicast*
   Date Graduated: Spring 2004
   First Position: President and CTO, Mosaic Networking
3. Sami Rollins
   Dissertation Title: *Overcoming Resource Constraints to Enable Content Exchange Applications in Next-Generation Environments*
   Date Graduated: Spring 2003
   First Position: Assistant Professor, Mount Holyoke College
2. Srinivasan Jagannathan
   Dissertation Title: *Multicast Tree-Based Congestion Control and Topology Management*
   Date Graduated: Spring 2003
   First Position: Consultant, Kelly & Associates
1. Kamil Sarac
   Dissertation Title: *Supporting a Robust Multicast Service in the Global Infrastructure*
   Date Graduated: Spring 2002
   First Position: Assistant Professor, UT-Dallas

D. M.S. Students Advised (Thesis/Project Option) [19 graduated]

19. Neer Shey
    Research Area: *Analyzing Content Distribution Through Opportunistic Contact for Smart Cellular Phones*
    Date Graduated: Spring 2010
18. Camilla Fiorese
    Research Area: *Analysis of a Pure Rate-Based Congestion Control Algorithm*
    Date Graduated: Summer 2009
17. Brian Weiner
    Research Area: *Multi-Socket TCP: A Simple Approach to Improve Performance of Real-Time Applications over TCP*
    Date Graduated: Fall 2007
16. Avijit Sen Mazumder
    Research Area: *Facilitating Robust Multicast Group Management*
    Date Graduated: Fall 2005
15. Rishi Matthew
    Thesis Title: *Providing Seamless Access to Multimedia Content on Heterogeneous Platforms*
    Date Graduated: Summer 2004
14. Camden Ho
    Research Area: *Tools and Techniques for Wireless Network Management*
    Date Graduated: Spring 2004
13. Amit Jardosh (co-advised with E. Belding)
    Research Area: *Realistic Environment Models for Mobile Network Evaluation*
    Date Graduated: Spring 2004

12. Nitin Solanki
    Research Area: *SongWand: A Wireless Barcode Scanner Using Bluetooth Technology*
    Date Graduated: Winter 2004
11. Vrishali Wagle (co-advised with E. Belding)
    Research Area: *An Ontology-Based Service Discovery Mechanism*
    Date Graduated: Winter 2004
10. Uday Mohan
    Thesis Title: *Scalable Service Discovery in Mobile Ad hoc Networks*
    Date Graduated: Spring 2003
9. Krishna Ramachandran
    Thesis Title: *Ubiquitous Multicast*
    Date Graduated: Spring 2003
8. John Slonaker
    Thesis Title: *Inductive Loop Signature Acquisition Techniques*
    Date Graduated: Spring 2002
7. Mohammad Battah
    Thesis Title: *Dedicated Short-Range Communications Intelligent Transportation Systems Protocol (DSRC-ITS)*
    Date Graduated: Spring 2002
6. Kevin Vogel
    Thesis Title: *Integrating E-Commerce Applications into Existing Business Infrastructures*
    Date Graduated: Spring 2001
5. Sami Rollins
    Thesis Title: *Audio XmL: Aural Interaction with XML Documents*
    Date Graduated: Winter 2000
4. Andy Davis
    Thesis Title: *Stream Scheduling for Data Servers in a Scalable Interactive TV System*
    Date Graduated: Spring 1999
3. David Makofske
    Thesis Title: *MHealth: A Real-Time Graphical Multicast Monitoring Tool*
    Date Graduated: Winter 1999
2. Prashant Rajvaidya
    Thesis Title: *MANTRA: Router-Based Monitoring and Analysis of Multicast Traffic*
    Date Graduated: Winter 1999
1. Alex DeCastro (co-advised with Yuan-Fang Wang)
    Thesis Title: *Web-Based Collaborative 3D Modeling*
    Date Graduated: Winter 1998

E. Teaching Awards

2006-2007 UCSB Academic Senate Distinguished Teaching Award
2004-2005 Computer Science Outstanding Faculty Member
2000-2001 UCSB Spotlight on Excellence Award
1999-2000 Computer Science Outstanding Faculty Member (co-recipient)
1998-1999 Computer Science Outstanding Faculty Member (co-recipient)
1997-1998 Computer Science Outstanding Faculty Member

II. Research

A. Journal Papers, Magazine Articles, Books, and Book Chapters

62. L. Deek, E. Garcia-Villegas, E. Belding, S.J. Lee, and K. Almeroth, "A Practical Framework for 802.11 MIMO Rate Adaptation," Computer Networks, vol. 83, num. 6, pp. 332-348, June 2015.

61. L. Deek, E. Garcia-Villegas, E. Belding, S.J. Lee, and K. Almeroth, "Intelligent Channel Bonding in 802.11n WLANs," IEEE Transactions on Mobile Computing, vol. 13, num. 6, pp. 1242-1255, June 2014.

60. H. Zhang and K. Almeroth, "Alternatives for Monitoring and Limiting Network Access to Students in Network-Connected Classrooms," Journal of Interactive Learning Research (JILR), vol. 24, num. 3, pp. 237-265, July 2013.

59. M. Tavakolifard and K. Almeroth, "A Taxonomy to Express Open Challenges in Trust and Reputation Systems," Journal of Communications, vol. 7, num. 7, pp. 538-551, July 2012.

58. M. Tavakolifard and K. Almeroth, "Social Computing: An Intersection of Recommender Systems, Trust/Reputation Systems, and Social Networks," IEEE Network, vol. 26, num. 4, pp. 53-58, July/August 2012.

57. M. Tavakolifard, K. Almeroth, and P. Ozturk, "Subjectivity Handling of Ratings for Trust and Reputation Systems: An Abductive Reasoning Approach," International Journal of Digital Content Technology and its Applications (JDCTA), vol. 5, num. 11, pp. 359-377, November 2011.

56. R. Raghavendra, P. Acharya, E. Belding and K. Almeroth, "MeshMon: A Multi-Tiered Framework for Wireless Mesh Network Monitoring," Wireless Communications and Mobile Computing (WCMC) Journal, vol. 11, num. 8, pp. 1182-1196, August 2011.

55. A. Knight and K. Almeroth, "Automatic Plagiarism Detection with PAIRwise 2.0," Journal of Interactive Learning Research (JILR), vol. 22, num. 3, pp. 379-400, July 2011.

54. V. Kone, M. Zheleva, M. Wittie, B. Zhao, E. Belding, H. Zheng, and K. Almeroth, "AirLab: Consistency, Fidelity and Privacy in Wireless Measurements," ACM Computer Communications Review, vol. 41, num. 1, pp. 60-65, January 2011.

53. G. Swamynathan, K. Almeroth, and B. Zhao, "The Design of a Reliable Reputation System," Electronic Commerce Research Journal, vol. 10, num. 3-4, pp. 239-270, December 2010.

52. P. Acharya, A. Sharma, E. Belding, K. Almeroth and K. Papagiannaki, "Rate Adaptation in Congested Wireless Networks through Real-Time Measurements," IEEE Transactions on Mobile Computing, vol. 9, num. 11, pp. 1535-1550, November 2010.

51. R. Raghavendra, E. Belding, K. Papagiannaki, and K. Almeroth, "Unwanted Link Layer Traffic in Large IEEE 802.11 Wireless Networks," IEEE Transactions on Mobile Computing, vol. 9, num. 9, pp. 1212-1225, September 2010.

50. H. Zhang and K. Almeroth, "Moodog: Tracking Student Activity in Online Course Management Systems," Journal of Interactive Learning Research (JILR), vol. 21, num. 3, pp. 407-429, July 2010.

49. R. Chertov and K. Almeroth, "Qualitative Comparison of Link Shaping Techniques," International Journal of Communication Networks and Distributed Systems, vol. 5, num. 1/2, pp. 109-129, July 2010.

48. A. Knight and K. Almeroth, "Fast Caption Alignment for Automatic Indexing of Audio," International Journal of Multimedia Data Engineering and Management, vol. 1, num. 2, pp. 1-17, April-June 2010.

47. K. Harras and K. Almeroth, "Scheduling Messengers in Disconnected Clustered Mobile Networks," Ad Hoc & Sensor Wireless Networks, vol. 9, num. 3-4, pp. 275-304, March-April 2010.

46. A. Jardosh, K. Papagiannaki, E. Belding, K. Almeroth, G. Iannaccone, and B. Vinnakota, "Green WLANs: On-Demand WLAN Infrastructures," ACM Journal on Mobile Networks and Applications (MONET), vol. 14, num. 6, pp. 798-814, December 2009.

45. M. Wittie, K. Harras, K. Almeroth, and E. Belding, "On the Implications of Routing Metric Staleness in Delay Tolerant Networks," Computer Communications Special Issue on Delay and Disruption Tolerant Networking, vol. 32, num. 16, pp. 1699-1709, October 2009.

44. K. Harras, L. Deek, C. Holman, and K. Almeroth, "DBS-IC: An Adaptive Data Bundling System for Intermittent Connectivity," Computer Communications Special Issue on Delay and Disruption Tolerant Networking, vol. 32, num. 16, pp. 1687-1698, October 2009.

43. S. Karpinski, E. Belding, K. Almeroth, and J. Gilbert, "Linear Representations of Network Traffic," ACM Journal on Mobile Networks and Applications (MONET), vol. 14, num. 4, pp. 368-386, August 2009.

42. K. Harras and K. Almeroth, "Controlled Flooding in Disconnected Sparse Mobile Networks," Wireless Communications and Mobile Computing (WCMC) Journal, vol. 9, num. 1, pp. 21-33, January 2009.

41. R. Mayer, A. Stull, K. DeLeeuw, K. Almeroth, B. Bimber, D. Chun, M. Bulger, J. Campbell, A. Knight, and H. Zhang, "Clickers in College Classrooms: Fostering Learning with Questioning Methods in Large Lecture Classes," Contemporary Educational Psychology, vol. 34, num. 1, pp. 51-57, January 2009.

40. A. Knight, K. Almeroth, and B. Bimber, "Design, Implementation and Deployment of PAIRwise," Journal of Interactive Learning Research (JILR), vol. 19, num. 3, pp. 489-508, July 2008.

39. A. Garyfalos and K. Almeroth, "Coupons: A Multilevel Incentive Scheme for Information Dissemination in Mobile Networks," IEEE Transactions on Mobile Computing, vol. 7, num. 6, pp. 792-804, June 2008.

38. I. Sheriff, K. Ramachandran, E. Belding, and K. Almeroth, "A Multi-Radio 802.11 Mesh Network Architecture," ACM Journal on Mobile Networks and Applications (MONET), vol. 13, num. 1-2, pp. 132-146, April 2008.

37. M. Bulger, R. Mayer, K. Almeroth, and S. Blau, "Measuring Learner Engagement in Computer-Equipped College Classrooms," Journal of Educational Multimedia and Hypermedia, vol. 17, num. 2, pp. 129-143, April 2008.

36. G. Swamynathan, B. Zhao, and K. Almeroth, "Exploring the Feasibility of Proactive Reputations," Concurrency and Computation: Practice and Experience, vol. 20, num. 2, pp. 155-166, February 2008.

35. G. Swamynathan, B. Zhao, K. Almeroth, and H. Zheng, "Globally Decoupled Reputations for Large

Distributed Networks," Advances in Multimedia, vol. 2007, pp. 1-14, 2007.

34. R. Mayer, A. Stull, J. Campbell, K. Almeroth, B. Bimber, D. Chun and A. Knight, "Overestimation Bias in Self-reported SAT Scores," Educational Psychology Review, vol. 19, num. 4, pp. 443-454, December 2007.

33. P. Namburi, K. Sarac and K. Almeroth, "Practical Utilities for Monitoring Multicast Service Availability," Computer Communications Special Issue on Monitoring and Measurement of IP Networks, vol. 29, num. 10, pp. 1675-1686, June 2006.

32. R. Chalmers, G. Krishnamurthi and K. Almeroth, "Enabling Intelligent Handovers in Heterogeneous Wireless Networks," ACM Journal on Mobile Networks and Applications (MONET), vol. 11, num. 2, pp. 215-227, April 2006.

31. H. Lundgren, K. Ramachandran, E. Belding, K. Almeroth, M. Benny, A. Hewatt, A. Touma and A. Jardosh, "Experience from the Design, Deployment and Usage of the UCSB MeshNet Testbed," IEEE Wireless Communications, vol. 13, num. 2, pp. 18-29, April 2006.

30. R. Mayer, K. Almeroth, B. Bimber, D. Chun, A. Knight and A. Campbell, "Technology Comes to College: Understanding the Cognitive Consequences of Infusing Technology in College Classrooms," Educational Technology, vol. 46, num. 2, pp. 48-53, March-April 2006.

29. A. Garyfalos and K. Almeroth, "A Flexible Overlay Architecture for Mobile IPv6 Multicast," Journal on Selected Areas in Communications (JSAC) Special Issue on Wireless Overlay Networks Based on Mobile IPv6, vol. 23, num. 11, pp. 2194-2205, November 2005.

28. K. Sarac and K. Almeroth, "Monitoring IP Multicast in the Internet: Recent Advances and Ongoing Challenges," IEEE Communications, vol. 43, num. 10, pp. 85-91, October 2005.

27. K. Sarac and K. Almeroth, "Application Layer Reachability Monitoring for IP Multicast," Computer Networks, vol. 48, num. 2, pp. 195-213, June 2005.

26. A. Jardosh, E. Belding, K. Almeroth and S. Suri, "Real-world Environment Models for Mobile Network Evaluation," Journal on Selected Areas in Communications Special Issue on Wireless Ad hoc Networks, vol. 23, num. 3, pp. 622-632, March 2005.

25. S. Rollins and K. Almeroth, "Evaluating Performance Tradeoffs in a One-to-Many Peer Content Distribution Architecture," Journal of Internet Technology, vol. 5, num. 4, pp. 373-387, Fall 2004.

24. K. Sarac and K. Almeroth, "Tracetree: A Scalable Mechanism to Discover Multicast Tree Topologies in the Network," IEEE/ACM Transactions on Networking, vol. 12, num. 5, pp. 795-808, October 2004.

23. K. Sarac and K. Almeroth, "A Distributed Approach for Monitoring Multicast Service Availability," Journal of Network and Systems Management, vol. 12, num. 3, pp. 327-348, September 2004.

22. P. Rajvaidya, K. Ramachandran and K. Almeroth, "Managing and Securing the Global Multicast Infrastructure," Journal of Network and Systems Management, vol. 12, num. 3, pp. 297-326, September 2004.

21. P. Rajvaidya and K. Almeroth, "Multicast Routing Instabilities," IEEE Internet Computing, vol. 8, num. 5, pp. 42-49, September/October 2004.

20. D. Johnson, R. Patton, B. Bimber, K. Almeroth and G. Michaels, "Technology and Plagiarism in the

University: Brief Report of a Trial in Detecting Cheating," Association for the Advancement of Computing in Education (AACE) Journal, vol. 12, num. 3, pp. 281-299, Summer 2004.

19. R. Chalmers and K. Almeroth, "A Security Architecture for Mobility-Related Services," Journal of Wireless Personal Communications, vol 29, num. 3, pp. 247-261, June 2004.

18. B. Stiller, K. Almeroth, J. Altmann, L. McKnight, and M. Ott, "Pricing for Content in the Internet," Computer Communications, vol. 27, num. 6, pp. 522-528, April 2004.

17. S. Rollins and K. Almeroth, "Lessons Learned Deploying a Digital Classroom," Journal of Interactive Learning Research (JILR), vol. 15, num. 2, pp. 169-185, April 2004.

16. S. Jagannathan and K. Almeroth, "A Dynamic Pricing Scheme for E-Content at Multiple Levels-of-Service," Computer Communications, vol. 27, num. 4, pp. 374-385, March 2004.

15. K. Almeroth, "Using Satellite Links in the Delivery of Terrestrial Multicast Traffic," Internetworking and Computing over Satellites, Kluwer Academic Publishers, 2003.

14. R. Chalmers and K. Almeroth, "On the Topology of Multicast Trees," IEEE/ACM Transactions on Networking, vol. 11, num. 1, pp. 153-165, January 2003.

13. S. Jagannathan, J. Nayak, K. Almeroth, and M. Hofmann, "On Pricing Algorithms for Batched Content Delivery Systems," Electronic Commerce Research and Applications Journal, vol. 1, num. 3-4, pp. 264-280, Fall 2002.

12. D. Makofske and K. Almeroth, "Multicast Sockets: Practical Guide for Programmers," *Morgan Kaufmann Publishers*, November 2002.

11. S. Jagannathan and K. Almeroth, "Price Issues in Delivering E-Content On-Demand," ACM Sigecom Exchanges, vol. 3, num. 2, pp. 18-27, May 2002.

10. D. Makofske and K. Almeroth, "From Television to Internet Video-on-Demand: Techniques and Tools for VCR-Style Interactivity," Software: Practice and Experience, vol. 31, num. 8, pp. 781-801, July 2001.

9. K. Sarac and K. Almeroth, "Supporting Multicast Deployment Efforts: A Survey of Tools for Multicast Monitoring," Journal on High Speed Networking, Special Issue on Management of Multimedia Networking, vol. 9, num. 3/4, pp. 191-211, March 2001.

8. K. Almeroth, "Adaptive, Workload-Dependent Scheduling for Large-Scale Content Delivery Systems," Transactions on Circuits and Systems for Video Technology, *Special Issue on Streaming Video*, vol. 11, num. 3, pp. 426-439, March 2001.

7. D. Makofske and K. Almeroth, "Real-Time Multicast Tree Visualization and Monitoring," Software: Practice and Experience, vol. 30, num. 9, pp. 1047-1065, July 2000.

6. M. Ammar, K. Almeroth, R. Clark and Z. Fei, "Multicast Delivery of WWW Pages," Electronic Commerce Technology Trends: Challenges and Opportunities, IBM Press, February 2000.

5. K. Almeroth, "The Evolution of Multicast: From the MBone to Inter-Domain Multicast to Internet2 Deployment," IEEE Network Special Issue on Multicasting, vol. 10, num. 1, pp. 10-20, January/February 2000.

4. K. Almeroth and M. Ammar, "An Alternative Paradigm for Scalable On-Demand Applications: Evaluating and Deploying the Interactive Multimedia Jukebox," IEEE Transactions on Knowledge and Data Engineering Special Issue on Web Technologies, vol. 11, num. 4, pp 658-672, July/August 1999.

3. K. Almeroth and M. Ammar, "The Interactive Multimedia Jukebox (IMJ): A New Paradigm for the On-Demand Delivery of Audio/Video," Computer Networks and ISDN Systems, vol. 30, no. 1, April 1998.

2. K. Almeroth and M. Ammar, "Multicast Group Behavior in the Internet's Multicast Backbone (MBone)," IEEE Communications, vol. 35, no. 6, pp. 124-129, June 1997.

1. K. Almeroth and M. Ammar, "On the Use of Multicast Delivery to Provide a Scalable and Interactive Video-on-Demand Service," Journal on Selected Areas of Communication (JSAC), vol. 14, no. 6, pp. 1110-1122, August 1996.

B. Conference Papers with Proceedings (refereed)

89. D. Havey and K. Almeroth, "Active Sense Queue Management (ASQM)," *IFIP Networking Conference*, Toulouse, FRANCE, May 2015.

88. L. Deek, E. Garcia-Villegas, E. Belding, S.J. Lee, and K. Almeroth, "Joint Rate and Channel Width Adaptation in 802.11 MIMO Wireless Networks," IEEE Conference on Sensor, Mesh and Ad Hoc Communications and Networks (SECON), New Orleans, LA, USA, June 2013.

87. D. Havey and K. Almeroth, "Fast Wireless Protocol: A Network Stack Design for Wireless Transmission," *IFIP Networking Conference*, Brooklyn, New York, USA, May 2013.

86. M. Tavakolifard, J. Gulla, K. Almeroth, J. Ingvaldsen, G. Nygreen, and E. Berg, "Tailored News in the Palm of Your HAND: A Multi-Perspective Transparent Approach to News Recommendation," *Demo Track at the International World Wide Web Conference (WWW)*, Rio de Janeiro, BRAZIL, May 2013.

85. S. Patterson, M. Wittie, K. Almeroth, and B. Bamieh, "Network Optimization with Dynamic Demands and Link Prices," *Allerton Conference*, Monticello, Illinois, USA, October 2012.

84. D. Havey, R. Chertov, and K. Almeroth, "Receiver Driven Rate Adaptation," *ACM Multimedia Systems Conference (MMSys)*, Chapel Hill, North Carolina, USA, February 2012.

83. M. Tavakolifard and K. Almeroth, "Trust 2.0: Who to Believe in the Flood of Online Data?" *International Conference on Computing, Networking and Communications (ICNC)*, Maui, Hawaii, USA, January 2012.

82. L. Deek, E. Garcia-Villegas, E. Belding, S.J. Lee, and K. Almeroth, "The Impact of Channel Bonding on 802.11n Network Management," *ACM CoNEXT*, Tokyo, JAPAN, December 2011.

81. L. Deek, X. Zhou, K. Almeroth, and H. Zheng, "To Preempt or Not: Tackling Bid and Time-based Cheating in Online Spectrum Auctions," *IEEE Infocom*, Shanghai, CHINA, April 2011.

80. M. Wittie, V. Pejovic, L. Deek, K. Almeroth, and B. Zhao, "Exploiting Locality of Interest in Online Social Networks," *ACM CoNEXT*, Philadelphia, Pennsylvania, USA, November 2010.

79. R. Chertov and K. Almeroth, "Using BGP in a Satellite-Based Challenged Network Environment,"

IEEE Conference on Sensor, Mesh and Ad Hoc Communications and Networks (SECON), Boston, Massachusetts, USA, June 2010.

78. R. Chertov, D. Havey and K. Almeroth, "MSET: A Mobility Satellite Emulation Testbed," *IEEE Infocom*, San Diego, California, USA, March 2010.

77. B. Stone-Gross, A. Moser, C. Kruegel, E. Kirda, and K. Almeroth, "FIRE: FInding Rogue nEtworks," *Annual Computer Security Applications Conference (ACSAC)*, Honolulu, Hawaii, USA, December 2009.

76. M. Wittie, K. Almeroth, E. Belding, I. Rimac, and V. Hilt, "Internet Service in Developing Regions Through Network Coding," *IEEE Conference on Sensor, Mesh and Ad Hoc Communications and Networks (SECON)*, Rome, ITALY, June 2009.

75. R. Chertov and K. Almeroth, "High-Fidelity Link Shaping," *International Conference on Testbeds and Research Infrastructures for the Development of Networks and Communities (TRIDENTCOM)*, Washington DC, USA, April 2009.

74. L. Deek, K. Almeroth, M. Wittie, and K. Harras, "Exploiting Parallel Networks Using Dynamic Channel Scheduling," *International Wireless Internet Conference (WICON)*, Maui, Hawaii, USA, November 2008.

73. D. Havey, E. Barlas, R. Chertov, K. Almeroth, and E. Belding, "A Satellite Mobility Model for QUALNET Network Simulations," *IEEE Military Communications Conference (MILCOM)*, San Diego, California, USA, November 2008.

72. J. Kayfetz and K. Almeroth, "Creating Innovative Writing Instruction for Computer Science Graduate Students," *ASEE/IEEE Frontiers in Education (FIE) Conference*, Saratoga Springs, New York, USA, October 2008.

71. G. Swamynathan, B. Zhao, K. Almeroth, and S. Rao, "Towards Reliable Reputations for Dynamic Networked Systems," *IEEE International Symposium on Reliable Distributed Systems (SRDS)*, Napoli, ITALY, October 2008.

70. B. Stone-Gross, D. Sigal, R. Cohn, J. Morse, K. Almeroth, and C. Krugel, "VeriKey: A Dynamic Certificate Verification System for Public Key Exchanges," *Conference on Detection of Intrusions and Malware & Vulnerability Assessment (DIMVA)*, Paris, FRANCE, July 2008.

69. P. Acharya, A. Sharma, E. Belding, K. Almeroth, K. Papagiannaki, "Congestion-Aware Rate Adaptation in Wireless Networks: A Measurement-Driven Approach," *IEEE Conference on Sensor, Mesh and Ad Hoc Communications and Networks (SECON)*, San Francisco, California, USA, June 2008.

68. A. Jardosh, P. Suwannatat, T. Hollerer, E. Belding, and K. Almeroth, "SCUBA: Focus and Context for Real-time Mesh Network Health Diagnosis," *Passive and Active Measurement Conference (PAM)*, Cleveland, Ohio, USA, April 2008.

67. B. Stone-Gross, C. Wilson, K. Almeroth, E. Belding, H. Zheng, K. Papagiannaki, "Malware in IEEE 802.11 Wireless Networks," *Passive and Active Measurement Conference (PAM)*, Cleveland, Ohio, USA, April 2008.

66. R. Raghavendra, E. Belding, K. Papagiannaki, and K. Almeroth, "Understanding Handoffs in Large IEEE 802.11 Wireless Networks," *Internet Measurement Conference (IMC)*, San Diego, California,

USA, October 2007.

65. M. Wittie, B. Stone-Gross, K. Almeroth and E. Belding, "MIST: Cellular Data Network Measurement for Mobile Applications," *IEEE International Conference on Broadband Communications, Networks, and Systems (BroadNets)*, Raleigh, North Carolina, USA, September 2007.

64. S. Karpinski, E. Belding, K. Almeroth, "Wireless Traffic: The Failure of CBR Modeling," *IEEE International Conference on Broadband Communications, Networks, and Systems (BroadNets)*, Raleigh, North Carolina, USA, September 2007.

63. A. Knight, K. Almeroth, H. Zhang, R. Mayer, and K. DeLeeuw, "Data Cafe: A Dining Car Approach to Educational Research Data Management and Distribution," *World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED MEDIA)*, Vancouver, CANADA, June 2007.

62. H. Zhang, K. Almeroth, A. Knight, M. Bulger, and R. Mayer, "Moodog: Tracking Students' Online Learning Activities," *World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED MEDIA)*, Vancouver, CANADA, June 2007.

61. M. Bulger, K. Almeroth, R. Mayer, D. Chun, A. Knight, H. Collins, "Effects of Instructor Engagement on Student Use of a Course Management System," Assocation for Psychological Science (APS) Annual Conference, Washington DC, USA, May 2007.

60. R. Mayer, A. Stull, K. Almeroth, B. Bimber, D. Chun, M. Bulger, J. Campbell, Allan Knight, and H. Zhang, "Using Technology-Based Methods to Foster Learning in Large Lecture Classes: Evidence for the Pedagogic Value of Clickers," *American Educational Research Association (AERA) Annual Conference*, Chicago, Illinois, USA, April 2007.

59. K. Ramachandran, I. Sheriff, E. Belding, and K. Almeroth, "Routing Stability in Static Wireless Mesh Networks," *Passive and Active Measurement Conference (PAM)*, Louvain-la-neuve, BELGIUM, April 2007.

58. G. Swamynathan, T. Close, S. Banerjee, R. McGeer, B. Zhao, and K. Almeroth, "Scalable Access Control For Web Services," *International Conference on Creating, Connecting and Collaborating through Computing (C5)*, Kyoto, JAPAN, January 2007.

57. A. Knight, M. Bulger, K. Almeroth, and H. Zhang, "Is Learning Really a Phone Call Away? Knowledge Transfer in Mobile Learning," *World Conference on Mobile Learning (mLearn)*, Banff, Alberta, CANADA, October 2006.

56. J. Kurian, K. Sarac, and K. Almeroth, "Defending Network-Based Services Against Denial of Service Attacks," *International Conference on Computer Communication and Networks (IC3N)*, Arlington, Virginia, USA, October 2006.

55. A. Jardosh, K. Sanzgiri, E. Belding and K. Almeroth, "IQU: Practical Queue-Based User Association Management for WLANs--Case Studies, Architecture, and Implementation," ACM Mobicom, Marina del Rey, California, USA, September 2006.

54. C. Holman, K. Harras, and K. Almeroth, "A Proactive Data Bundling System for Intermittent Mobile Connections," IEEE International Conference on Sensor and Ad Hoc Communications and Networks (SECON), Reston, Virginia, USA, September 2006.

53. G. Banks, M. Cova, V. Felmetsger, K. Almeroth, R. Kemmerer and G. Vigna, "SNOOZE: toward a Stateful NetwOrk prOtocol fuzZEr," *Information Security Conference (ISC)*, Samos Island, GREECE,

September 2006.

52. K. Harras and K. Almeroth, "Inter-Regional Messenger Scheduling in Delay Tolerant Mobile Networks," *IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM)*, Niagara Falls, New York, USA, June 2006.

51. M. Bulger, R. Mayer, and K. Almeroth, "Engaged By Design: Using Simulation to Promote Active Learning," **Outstanding Paper** at the *World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED MEDIA)*, Orlando, Florida, USA, June 2006.

50. A. Knight, K. Almeroth, R. Mayer, D. Chun, and B. Bimber, "Observations and Recommendations for Using Technology to Extend Interaction," *World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED MEDIA)*, Orlando, Florida, USA, June 2006.

49. H. Zhang, and K. Almeroth, "A Simple Classroom Network Access Control System," *World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED MEDIA)*, Orlando, Florida, USA, June 2006.

48. K. Harras and K. Almeroth, "Transport Layer Issues in Delay Tolerant Mobile Networks," *IFIP Networking Conference*, Coimbra, PORTUGAL, May 2006.

47. R. Mayer, A. Stull, J. Campbell, K. Almeroth, B. Bimber, D. Chun and A. Knight, "Some Shortcomings of Soliciting Students' Self-Reported SAT Scores," *American Educational Research Association (AERA) Annual Conference*, San Francisco, California, USA, April 2006.

46. K. Ramachandran, E. Belding, K. Almeroth, and M. Buddhikot, "Interference-Aware Channel Assignment in Multi-Radio Wireless Mesh Networks," *IEEE Infocom*, Barcelona, SPAIN, April 2006.

45. A. Jardosh, K. Ramachandran, K. Almeroth, and E. Belding, "Understanding Congestion in IEEE 802.11b Wireless Networks," *ACM/USENIX Internet Measurement Conference (IMC)*, Berkeley, California, USA, October 2005.

44. H. Zhang, K. Almeroth and M. Bulger, "An Activity Monitoring System to Support Classroom Research," *World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED MEDIA)*, Montreal, Quebec, CANADA, pp. 1444-1449, June 2005.

43. Z. Xiang, H. Zhang, J. Huang, S. Song and K. Almeroth, "A Hidden Environment Model for Constructing Indoor Radio Maps," *IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM)*, Taormina, ITALY, June 2005.

42. K. Harras, K. Almeroth and E. Belding, "Delay Tolerant Mobile Networks (DTMNs): Controlled Flooding in Sparse Mobile Networks," *IFIP Networking Conference*, Waterloo, Ontario, CANADA, May 2005.

41. A. Garyfalos and K. Almeroth, "Coupons: Wide Scale Information Distribution for Wireless Ad Hoc Networks," *IEEE Global Telecommunications Conference (Globecom) Global Internet and Next Generation Networks Symposium*, Dallas, Texas, USA, pp. 1655-1659, December 2004.

40. A. Knight and K. Almeroth, "DeCAF: A Digital Classroom Application Framework," *IASTED International Conference on Communications, Internet and Information Technology (CIIT)*, St. Thomas, US Virgin Islands, November 2004.

39. P. Namburi, K. Sarac and K. Almeroth, "SSM-Ping: A Ping Utility for Source Specific Multicast,"

IASTED International Conference on Communications, Internet and Information Technology (CIIT), St. Thomas, US Virgin Islands, November 2004.

38. K. Ramachandran, E. Belding and K. Almeroth, "DAMON: A Distributed Architecture for Monitoring Multi-hop Mobile Networks," *IEEE International Conference on Sensor and Ad Hoc Communications and Networks (SECON)*, Santa Clara, California, USA, October 2004.

37. A. Garyfalos and K. Almeroth, "Coupon Based Incentive Systems and the Implications of Equilibrium Theory," *IEEE Conference on Electronic Commerce (CEC)*, San Diego, California, USA, pp. 213-220, July 2004.

36. A. Knight, K. Almeroth and B. Bimber, "An Automated System for Plagiarism Detection Using the Internet," *World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED MEDIA)*, Lugano, Switzerland, pp. 3619-3625, June 2004.

35. H. Zhang and K. Almeroth, "Supplement to Distance Learning: Design for a Remote TA Support System," *World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED MEDIA)*, Lugano, Switzerland, pp. 2821-2830, June 2004.

34. U. Mohan, K. Almeroth and E. Belding, "Scalable Service Discovery in Mobile Ad hoc Networks," *IFIP Networking Conference*, Athens, Greece, pp. 137-149, May 2004.

33. V. Thanedar, K. Almeroth and E. Belding, "A Lightweight Content Replication Scheme for Mobile Ad hoc Environments," *IFIP Networking Conference*, Athens, Greece, pp. 125-136, May 2004.

32. R. Chalmers and K. Almeroth, "A Mobility Gateway for Small-Device Networks," *IEEE International Conference on Pervasive Computing and Communications (PerCom)*, Orlando, Florida, USA, March 2004.

31. A. Jardosh, E. Belding, K. Almeroth and S. Suri, "Towards Realistic Mobility Models For Mobile Ad hoc Networks," *ACM Mobicom*, San Diego, California, USA, September 2003.

30. K. Sarac, P. Namburi and K. Almeroth, "SSM Extensions: Network Layer Support for Multiple Senders in SSM," *International Conference on Computer Communication and Networks (IC3N)*, Dallas, Texas, USA, October 2003.

29. K. Ramachandran and K. Almeroth, "MAFIA: A Multicast Management Solution for Access Control and Traffic Filtering," *IEEE/IFIP Conference on Management of Multimedia Networks and Services (MMNS)*, Belfast, Northern Ireland, September 2003.

28. J. Humfrey, S. Rollins, K. Almeroth, and B. Bimber, "Managing Complexity in a Networked Learning Environment," *World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED MEDIA)*, Honolulu, Hawaii, USA, pp. 60-63, June 2003.

27. K. Almeroth, S. Rollins, Z. Shen, and B. Bimber, "Creating a Demarcation Point Between Content Production and Encoding in a Digital Classroom," *World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED MEDIA)*, Honolulu, Hawaii, USA, pp. 2-5, June 2003.

26. M. Kolsch, K. Kvilekval, and K. Almeroth, "Improving Speaker Training with Interactive Lectures," *World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED MEDIA)*, Honolulu, Hawaii, USA, June 2003.

25. P. Rajvaidya and K. Almeroth, "Analysis of Routing Characteristics in the Multicast Infrastructure,"

IEEE Infocom, San Francisco, California, USA, April 2003.

24. S. Rollins and K. Almeroth, "Pixie: A Jukebox Architecture to Support Efficient Peer Content Exchange," *ACM Multimedia*, Juan Les Pins, FRANCE, December 2002.

23. S. Rollins, R. Chalmers, J. Blanquer, and K. Almeroth, "The Active Information System(AIS): A Model for Developing Scalable Web Services," *IASTED International Conference on Internet and Multimedia Systems and Applications (IMSA)*, Kauai, Hawaii, USA, August 2002.

22. S. Rollins and K. Almeroth, "Seminal: Additive Semantic Content for Multimedia Streams," *IASTED International Conference on Internet and Multimedia Systems and Applications (IMSA)*, Kauai, Hawaii, USA, August 2002.

21. B. Stiller, K. Almeroth, J. Altmann, L. McKnight, and M. Ott, "Content Pricing in the Internet," *SPIE ITCom Conference on Internet Performance and Control of Network Systems (IPCNS)*, Boston, Massachusetts, USA, July 2002.

20. S. Jagannathan, J. Nayek, K. Almeroth and M. Hofmann, "A Model for Discovering Customer Value for E-Content," *ACM International Conference on Knowledge Discovery and Data Mining (SIGKDD)*, Edmonton, Alberta, CANADA, July 2002.

19. S. Rollins and K. Almeroth, "Deploying and Infrastructure for Technologically Enhanced Learning," **Outstanding Paper** at the *World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED MEDIA)*, Denver, Colorado, USA, pp. 1651-1656, June 2002.

18. P. Rajvaidya and K. Almeroth, "Building the Case for Distributed Global Multicast Monitoring," *Multimedia Computing and Networking (MMCN)*, San Jose, California, USA, January 2002.

17. S. Jagannathan and K. Almeroth, "An Adaptive Pricing Scheme for Content Delivery Systems," *IEEE Global Internet*, San Antonio, Texas, USA, November 2001.

16. K. Sarac and K. Almeroth, "Providing Scalable Many-to-One Feedback in Multicast Reachability Monitoring Systems," *IFIP/IEEE International Conference on Management of Multimedia Networks and Services (MMNS)*, Chicago, Illinois, USA, October 2001.

15. S. Jagannathan and K. Almeroth, "The Dynamics of Price, Revenue and System Utilization," *IFIP/IEEE International Conference on Management of Multimedia Networks and Services (MMNS)*, Chicago, Illinois, USA, October 2001.

14. A. Kanwar, K. Almeroth, S. Bhattacharyya, and M. Davy, "Enabling End-User Network Monitoring via the Multicast Consolidated Proxy Monitor," *SPIE ITCom Conference on Scalability and Traffic Control in IP Networks (STCIPN)*, Denver, Colorado, USA, August 2001.

13. S. Jagannathan and K. Almeroth, "Using Tree Topology for Multicast Congestion Control," *International Conference on Parallel Processing (ICPP)*, Valencia, SPAIN, September 2001.

12. P. Rajvaidya and K. Almeroth, "A Router-Based Technique for Monitoring the Next-Generation of Internet Multicast Protocols," *International Conference on Parallel Processing (ICPP)*, Valencia, SPAIN, September 2001.

11. R. Chalmers and K. Almeroth, "Modeling the Branching Characteristics and Efficiency Gains of Global Multicast Trees," *IEEE Infocom*, Anchorage, Alaska, USA, April 2001.

10. R. Chalmers and K. Almeroth, "Developing a Multicast Metric," *Global Internet*, San Francisco, California, USA, December 2000.

9. K. Sarac and K. Almeroth, "Monitoring Reachability in the Global Multicast Infrastructure," *IEEE International Conference on Network Protocols (ICNP)*, Osaka, JAPAN, November 2000.

8. K. Almeroth, "A Long-Term Analysis of Growth and Usage Patterns in the Multicast Backbone (MBone)," *IEEE INFOCOM*, Tel Aviv, ISRAEL, March 2000.

7. K. Almeroth, K. Obraczka and D. De Lucia, "A Lightweight Protocol for Interconnecting Heterogeneous Devices in Dynamic Environments," *IEEE International Conference on Multimedia Computing and Systems (ICMCS)*, Florence, ITALY, June 1999.

6. K. Almeroth and M. Ammar, "The Interactive Multimedia Jukebox (IMJ): A New Paradigm for the On-Demand Delivery of Audio/Video," **Best Paper** at *the Seventh International World Wide Web Conference (WWW)*, Brisbane, AUSTRALIA, April 1998.

5. K. Almeroth, M. Ammar and Z. Fei, "Scalable Delivery of Web Pages Using Cyclic Best-Effort (UDP) Multicast," *IEEE INFOCOM*, San Francisco, California, USA, June 1998.

4. K. Almeroth and M. Ammar, "Delivering Popular Web Pages Using Cyclic Unreliable Multicast (Extended Abstract)," *SPIE Conference on Voice, Video and Data Communications*, Dallas, Texas, USA, November 1997.

3. K. Almeroth, A. Dan, D. Sitaram and W. Tetzlaff, "Long Term Resource Allocation in Video Delivery Systems," *IEEE INFOCOM*,Kobe, JAPAN, April 1997.

2. K. Almeroth and M. Ammar, "On the Performance of a Multicast Delivery Video-On-Demand Service with Discontinuous VCR Actions," *International Conference on Communications (ICC)*, Seattle, Washington, USA, June 1995.

1. K. Almeroth and M. Ammar, "A Scalable, Interactive Video-On-Demand Service Using Multicast Communication," *International Conference on Computer Communication and Networks (IC3N)*, San Francisco, California, USA, September 1994.

C. Workshop Papers (refereed)

34. M. Tavakolifard, J. Gulla, K. Almeroth, F. Hopfgartner, B. Kille, T. Plumbaum, A. Lommatzsch, T. Brodt, A. Bucko, and T. Heintz, "Workshop and Challenge on News Recommender Systems," *ACM RecSys News Recommender Systems (NRS) Workshop and Challange*, Hong Kong, CHINA, October 2013.

33. M. Tavakolifard, K. Almeroth, and J. Gulla, "Does Social Contact Matter? Modelling the Hidden Web of Trust Underlying Twitter," *ACM International Workshop on Social Recommender Systems (SRS)*, Rio de Janeiro, BRAZIL, May 2013.

32. D. Johnson, E. Belding, K. Almeroth and G. van Stam, "Internet Usage and Performance Analysis of a Rural Wireless Network in Macha, Zambia," *ACM Networked Systems for Developing Regions (NSDR) Workshop*, San Francisco, California, USA, June 2010.

31. D. Havey, R. Chertov, and K. Almeroth, "Wired Wireless Broadcast Emulation," *International*

Workshop on Wireless Network Measurement (WiNMee), Seoul, Korea, June 2009.

30. R. Raghavendra, P. Acharya, E. Belding, and K. Almeroth, "MeshMon: A Multi-Tiered Framework for Wireless Mesh Network Monitoring," *ACM Mobihoc Wireless of the Students, by the Students, for the Students Workshop (S3)*, New Orleans, Louisiana, USA, May 2009.

29. G. Swamynathan, C. Wilson, B. Boe, B. Zhao, and K. Almeroth, "Do Social Networks Improve e-Commerce: A Study on Social Marketplaces," *ACM Sigcomm Workshop on Online Social Networks (WOSN)*, Seattle, Washington, USA, August 2008.

28. R. Raghavendra, E. Belding, and K. Almeroth, "Antler: A Multi-Tiered Approach to Automated Wireless Network Management," *IEEE Workshop on Automated Network Management (ANM)*, Phoenix, Arizona, USA, April 2008.

27. S. Karpinski, E. Belding, and K. Almeroth, "Towards Realistic Models of Wireless Workload," *International Workshop on Wireless Network Measurement (WiNMee)*, Limassol, CYPRUS, April 2007.

26. K. Harras, M. Wittie, K. Almeroth, and E. Belding, "ParaNets: A Parallel Network Architecture for Challenged Networks," *IEEE Workshop on Mobile Computing Systems and Applications (HotMobile)*, Tucson, Arizona, USA, February 2007.

25. H. Caituiro-Monge, K. Almeroth, M. del Mar Alvarez-Rohena, "Friend Relay: A Resource Sharing Framework for Mobile Wireless Devices," *ACM International Workshop on Wireless Mobile Applications and Services on WLAN Hotspots (WMASH)*, Los Angeles, California, September 2006.

24. G. Swamynathan, Ben Y. Zhao and K. Almeroth, "Exploring the Feasibility of Proactive Reputations," *International Workshop on Peer-to-Peer Systems (IPTPS)*, Santa Barbara, California, USA, February 2006.

23. G. Swamynathan, Ben Y. Zhao and K. Almeroth, "Decoupling Service and Feedback Trust in a Peer-to-Peer Reputation System," *International Workshop on Applications and Economics of Peer-to-Peer Systems (AEPP)*, Nanjing, CHINA, November 2005.

22. K. Ramachandran, M. Buddhikot, G. Chandranmenon, S. Miller, E. Belding, and K. Almeroth, "On the Design and Implementation of Infrastructure Mesh Networks," *IEEE Workshop on Wireless Mesh Networks (WiMesh)*, Santa Clara, California, USA, September 2005.

21. A. Jardosh, K. Ramachandran, K. Almeroth and E. Belding, "Understanding Link-Layer Behavior in Highly Congested IEEE 802.11b Wireless Networks," Sigcomm Workshop on Experimental Approaches to Wireless Network Design and Analysis (EWIND), Philadelphia, Pennsylvania, USA, August 2005.

20. A. Sen Mazumder, K. Almeroth and K. Sarac, "Facilitating Robust Multicast Group Management," *Network and Operating System Support for Digital Audio and Video (NOSSDAV)* , Skamania, Washington, USA, June 2005.

19. Y. Sun, I. Sheriff, E. Belding and K. Almeroth, "An Experimental Study of Multimedia Traffic Performance in Mesh Networks," MobiSys International Workshop on Wireless Traffic Measurements and Modeling (WitMeMo), Seattle, Washington, USA, June 2005.

18. K. Ramachandran, K. Almeroth and E. Belding, "A Framework for the Management of Large-Scale Wireless Network Testbeds," International Workshop on Wireless Network Measurement (WiNMee),

Trentino, ITALY, April 2005.

17. A. Garyfalos, K. Almeroth and K. Sanzgiri, "Deployment Complexity Versus Performance Efficiency in Mobile Multicast," *International Workshop on Broadband Wireless Multimedia: Algorithms, Architectures and Applications (BroadWiM)*, San Jose, California, USA, October 2004.

16. C. Ho, K. Ramachandran, K. Almeroth and E. Belding, "A Scalable Framework for Wireless Network Monitoring," *ACM International Workshop on Wireless Mobile Applications and Services on WLAN Hotspots (WMASH)*, Philadelphia, Pennsylvania, USA, October 2004.

15. A. Garyfalos, K. Almeroth and J. Finney, "A Hybrid of Network and Application Layer Multicast for Mobile IPv6 Networks," *International Workshop on Large-Scale Group Communication (LSGC)*, Florence, ITALY, October 2003.

14. A. Garyfalos, K. Almeroth and J. Finney, "A Comparison of Network and Application Layer Multicast for Mobile IPv6 Networks," *ACM Workshop on Modeling, Analysis and Simulation of Wireless and Mobile Systems (MSWiM)*, San Diego, California, USA, September 2003.

13. S. Jagannathan, and K. Almeroth, "Pricing and Resource Provisioning for Delivering E-Content On-Demand with Multiple Levels-of-Service," *International Workshop on Internet Charging and QoS Technologies (ICQT)*, Zurich, SWITZERLAND, October 2002.

12. S. Rollins, K. Almeroth, D. Milojicic, and K. Nagaraja, "Power-Aware Data Management for Small Devices," *Workshop on Wireless Mobile Multimedia (WoWMoM)*, Atlanta, GA, USA, September 2002.

11. K. Almeroth, S. Bhattacharyya, and C. Diot, "Challenges of Integrating ASM and SSM IP Multicast Protocol Architectures," *International Workshop on Digital Communications: Evolutionary Trends of the Internet (IWDC)*, Taormina, ITALY, September 2001.

10. K. Sarac and K. Almeroth, "Scalable Techniques for Discovering Multicast Tree Topology," *Network and Operating System Support for Digital Audio and Video (NOSSDAV)* , Port Jefferson, New York, USA, June 2001.

9. P. Rajvaidya, K. Almeroth and K. Claffy, "A Scalable Architecture for Monitoring and Visualizing Multicast Statistics," *IFIP/IEEE International Workshop on Distributed Systems: Operations & Management (DSOM)*, Austin, Texas, USA, December 2000.

8. S. Jagannathan, K. Almeroth and A. Acharya, "Topology Sensitive Congestion Control for Real-Time Multicast," *Network and Operating System Support for Digital Audio and Video (NOSSDAV)* , Chapel Hill, North Carolina, USA, June 2000.

7. K. Sarac and K. Almeroth, "Supporting the Need for Inter-Domain Multicast Reachability," *Network and Operating System Support for Digital Audio and Video (NOSSDAV)* , Chapel Hill , North Carolina, USA, June 2000.

6. D. Makofske and K. Almeroth, "MHealth: A Real-Time Multicast Tree Visualization and Monitoring Tool," *Network and Operating System Support for Digital Audio and Video (NOSSDAV)* , Basking Ridge New Jersey, USA, June 1999.

5. K. Almeroth and Y. Zhang, "Using Satellite Links as Delivery Paths in the Multicast Backbone (MBone)," *ACM/IEEE International Workshop on Satellite-Based Information Services (WOSBIS)*, Dallas, Texas, USA, October 1998.

4. M. Ammar, K. Almeroth, R. Clark and Z. Fei, "Multicast Delivery of Web Pages OR How to Make Web Servers Pushy," *Workshop on Internet Server Performance (WISP)*, Madison, Wisconsin, USA, June 1998.

3. K. Almeroth and M. Ammar, "Prototyping the Interactive Multimedia Jukebox," *Mini-conference on Multimedia Appliances, Interfaces, and Trials--International Conference on Communications (ICC)*, Montreal, Quebec, CANADA, June 1997.

2. K. Almeroth and M. Ammar, "Collection and Modeling of the Join/Leave Behavior of Multicast Group Members in the MBone," *High Performance Distributed Computing Focus Workshop (HPDC)*, Syracuse, New York, USA, August 1996.

1. K. Almeroth and M. Ammar, "The Role of Multicast Communication in the Provision of Scalable and Interactive Video-On-Demand Service," *Network and Operating System Support for Digital Audio and Video (NOSSDAV)* , Durham, New Hampshire, USA, April 1995.

D. Non-Refereed Publications

8. K. Almeroth, E. Belding, M. Buddhikot, G. Chandranmenon, S. Miller, and K. Ramachandran, "Infrastructure Mesh Networks," *U.S. Patent Application US20070070959 A1*, September 2005.

7. K. Almeroth, R. Caceres, A. Clark, R. Cole, N. Duffield, T. Friedman, K. Hedayat, K. Sarac, M. Westerlund, "RTP Control Protocol Extended Reports (RTCP XR)," *Internet Engineering Task Force (IETF) Request for Comments (RFC) 3611*, November 2003.

6. Z. Albanna, K. Almeroth, D. Meyer, and M. Schipper, "IANA Guidelines for IPv4 Multicast Address Allocation," *Internet Engineering Task Force (IETF) Request for Comments (RFC) 3171*, August 2001.

5. B. Quinn and K. Almeroth, "IP Multicast Applications: Challenges and Solutions," *Internet Engineering Task Force (IETF), Request for Comments (RFC) 3170*, September 2001.

4. K. Almeroth, L. Wei and D. Farinacci, "Multicast Reachability Monitor (MRM) Protocol," *Internet Engineering Task Force Internet Draft*, July 2000.

3. K. Almeroth and L. Wei, "Justification for and use of the Multicast Reachability Monitor (MRM) Protocol," *Internet Engineering Task Force Internet Draft*, March 1999.

2. K. Almeroth, "Managing IP Multicast Traffic: A First Look at the Issues, Tools, and Challenges," IP Multicast Initiative White Paper, San Jose, California, USA, February 1999.

1. K. Almeroth, K. Obraczka and D. De Lucia, "Pseudo-IP: Providing a Thin Network Protocol for Semi-Intelligent Wireless Devices," *DARPA/NIST Smart Spaces Workshop*, Gaithersburg, Maryland, USA, July 1998.

E. Released Software Systems

19. ***A Multi-radio Wireless Mesh Network Architecture -- http://moment.cs.ucsb.edu/tic/.*** Released December 1, 2006 (with K. Ramachandran, I. Sheriff, and E. Belding). The software as part of a multi-

radio wireless mesh network that includes a Split Wireless Router that alleviates the interference that can occur between commodity radios within a single piece of hardware. The second is server software to perform channel assignment and communicate the assignments throughout the mesh network.

18. ***AODV-Spanning Tree (AODV-ST) -- http://www.cs.ucsb.edu/~krishna/aodv-st/.*** Released September 1, 2006 (with K. Ramachandran and E. Belding). AODV-ST is an extension of the well-known AODV protocol specifically designed for wireless mesh networks. The advantages of AODV-ST over AODV include support for high throughput routing metrics, automatic route maintenance for common-case traffic, and low route discovery latency.

17. ***The Multicast Detective -- http://www.nmsl.cs.ucsb.edu/mcast_detective/.*** Released September 1, 2005 (with A. Sen Mazumder). The multicast detective is a robust solution to determine the existence and nature of multicast service for a particular user. By performing a series of tests, a user can determine whether there is network support for multicast, and consequently, whether a multicast group join is likely to succeed.

16. ***AutoCap: Automatic and Accurate Captioning -- http://www.nmsl.cs.ucsb.edu/autocap/.*** Released August 1, 2005 (with A. Knight). AutoCap is a software system that takes as input an audio/video file and a text transcript. AutoCap creates captions by aligning the utterances in the audio/video file to the transcript. For those words that are not recognized, AutoCap estimates when the words were spoken along with an error bound that gives the content creator an idea of caption accuracy. The result is a collection of accurately time-stamped captions that can be displayed with the video.

15. ***PAIRwise Plagiarism Detection System -- http://cits.ucsb.edu/pair/.*** Released July 1, 2005 (with A. Knight). PAIRwise is a plagiarism detection system with: (1) an easy-to-use interface for submitting papers, (2) a flexible comparison engine that allows intra-class, inter-class, and Internet-based comparisons, and (3) an intuitive graphical presentation of results.

14. ***DAMON Multi-Hop Wireless Network Monitoring -- http://moment.cs.ucsb.edu/damon/.*** Released October 1, 2004 (with K. Ramachandran and E. Belding). DAMON is a distributed system for monitoring multi-hop mobile networks. DAMON uses agents within the network to monitor network behavior and send collected measurements to data repositories. DAMON's generic architecture supports the monitoring of a wide range of protocol, device, or network parameters.

13. ***Multicast Firewall -- http://www.nmsl.cs.ucsb.edu/mafia/.*** Released June 1, 2004 (with K. Ramachandran). MAFIA, a multicast firewall and traffic management solution, has the specific aim of strengthening multicast security through multicast access control, multicast traffic filtering, and DoS attack prevention.

12. ***AODV@IETF Peer Routing Software-- http://moment.cs.ucsb.edu/aodv-ietf/.*** Released November 1, 2003 (with K. Ramachandran and E. Belding). One of the first large-scale efforts to run the Ad hoc On demand Distance Vector (AODV) routing protocol in a public space (at the Internet Engineering Task Force (IETF)). The implementation includes a daemon that runs on both the Linux and Windows operating systems.

11. ***Mobility Obstacles -- http://moment.cs.ucsb.edu/mobility/.*** Released September 1, 2003 (with A. Jardosh, E. Belding, and S. Suri). The topology and movement of nodes in ad hoc protocol simulation are key factors in protocol performance. In this project, we have developed ns-2 simulation plug-ins that create more realistic movement models through the incorporation of obstacles. These obstacles are utilized to restrict both node movement and wireless transmissions.

10. ***mwalk -- http://www.nmsl.cs.ucsb.edu/mwalk/.*** Released December 1, 2000 (with R. Chalmers).

Mwalk is a collection of Java applications and Perl scripts which re-create a global view of a multicast session from mtrace and RTCP logs. Users to the site can download mwalk, examine the results of our analysis, or download data sets for use in simulations dependent on multicast tree characteristics.

9. ***MANTRA2 -- http://www.nmsl.cs.ucsb.edu/mantra/.*** Released December 1, 1999 (with P. Rajvaidya). This new version of MANTRA focuses on the visualization of inter-domain routing statistics. Working in conjunction with the Cooperative Association for Internet Data Analysis (CAIDA) we have developed advanced collection and visualization techniques.

8. ***MRM -- http://www.nmsl.cs.ucsb.edu/mrm/.*** Released October 1, 1999 (with K. Sarac). MRM is the Multicast Reachability Protocol. We have implemented an end-host agent that responds to MRM Manager commands. Our end-host agent works in conjunction with Cisco routers to detect and isolate multicast faults.

7. ***MANTRA -- http://www.nmsl.cs.ucsb.edu/mantra/.*** Released January 1, 1999 (with P. Rajvaidya). MANTRA is the Monitoring and Analysis of Traffic in Multicast Routers. It uses scripts to collect and display data from backbone multicast routers.

6. ***SDR Monitor -- http://www.nmsl.cs.ucsb.edu/sdr-monitor/.*** Released January 1, 1999 (with K. Sarac). The SDR Monitor receives e-mail updates from participants containing information about observed sessions in the MBone. A global view of multicast reachability is then constructed.

5. ***The MHealth tool -- http://www.nmsl.cs.ucsb.edu/mhealth/.*** Released September 1, 1998 (with D. Makofske). The mhealth tool graphically visualizes MBone multicast group trees and provides `health' information including end-to-end losses per receiver and losses on a per hop basis. The implementation required expertise in Java, the MBone tools, and Unix.

4. ***The MControl tool -- http://www.nmsl.cs.ucsb.edu/mcontrol/.*** Released August 1, 1998 (with D. Makofske). Mcontrol is a tool to provide VCR-based interactivity for live MBone sessions. The implementation required expertise in Java, the MBone tools, and Unix.

3. ***Interactive Multimedia Jukebox (IMJ) -- http://imj.ucsb.edu/.*** Released October 1, 1996. The IMJ combines the WWW and the MBone conferencing tools to provide a multi-channel video jukebox offering both instructional and entertainment programming on a wide scale. The implementation required expertise in HTML, Perl, C, the MBone tools, and Unix.

2. ***Mlisten -- http://www.cc.gatech.edu/computing/Telecomm/mbone/.*** Released September 1, 1995. A tool to continuously collect MBone multicast group membership information including number and location of members, membership duration, and inter-arrival time for all audio and video sessions. The implementation required expertise in C, Tcl/Tk, the MBone tools, and UNIX socket programming.

1. ***Audio-on-Demand (AoD)***. March 1, 1995. A server/client prototype to demonstrate interactivity in near VoD systems. The AoD server provides songs-on-demand and VCR-like functions via multicast IP over Ethernet. The implementation required expertise in C, OpenWindows programming, UNIX socket programming, and network programming.

F. Tutorials, Panels and Invited Talks

- "25th Anniversary Panel," Network and Operating System Support for Digital Audio and Video (NOSSDAV), Portland, Oregon, USA, March 2015.

- "Sensing and Opportunistic Delivery of Ubiquitous Video in Health Monitoring, On-Campus and Social Network Applications," Workshop on Mobile Video Delivery (MoViD), Chapel Hill North Carolina, USA, February 2012.

- "Medium Access in New Contexts: Reinventing the Wheel?," USC Invited Workshop on Theory and Practice in Wireless Networks, Los Angeles, California, USA, May 2008.

- "The Wild, Wild West: Wireless Networks Need a New Sheriff," University of Florida CISE Department Lecture Series, Gainesville, Florida, USA, February 2008.

- "Distinguishing Between Connectivity, Intermittent Connectivity, and Intermittent Disconnectivity," Keynote at the ACM MobiCom Workshop on Challenged Networks (CHANTS), Montreal, CANADA, September 2007.

- "The Three Ghosts of Multicast: Past, Present, and Future," Keynote at the Trans-European Research and Education Networking Association (TERENA) Networking Conference, Lynby, DENMARK, May 2007.

- "Multicast Help Wanted: From Where and How Much?," Keynote at the Workshop on Peer-to-Peer Multicasting (P2PM), Las Vegas, Nevada, USA, January 2007.

- "The Confluence of Wi-Fi and Apps: What to Expect Next," Engineering Insights, UC-Santa Barbara, Santa Barbara, California, USA, October 2006.

- "Challenges, Opportunities, and Implications for the Future Internet," University of Minnesota Digital Technology Center, Minneapolis, Minnesota, USA, September 2006.

- "Wireless Technology as a Catalyst: Possibilities for Next-Generation Interaction," Santa Barbara Forum on Digital Transitions, Santa Barbara, California, USA, April 2006.

- "Challenges and Opportunities in an Internet with Pervasive Wireless Access," University of Texas--Dallas Computer Science Colloquium, Dallas, Texas, USA, March 2006.

- "Challenges and Opportunities with Pervasive Wireless in the Internet," Duke University Computer Science Colloquium, Durham, North Carolina, USA, February 2006.

- "The Span From Wireless Protocols to Social Applications," Intel Research Labs, Cambridge, United Kingdom, December 2005.

- "The Internet Dot.Com Bomb and Beyond the Dot.Com Calm," CSE IGERT and Cal Poly Lecture Series, San Luis Obispo, California, USA, October 2005.

- "Panel: Directions in Networking Research," IEEE Computer Communications Workshop (CCW), Irvine, California, USA, October 2005.

- "Economic Incentives for Ad Hoc Networks," KAIST New Applications Seminar, Seoul, South Korea, March 2004.

- "New Applications for the Next Generation Internet," Citrix Systems, Santa Barbara, California, USA, March 2004.

- "PI: The Imperfect Pursuit of Pure Pattern," CITS Visions in Technology Series, Santa Barbara,

California, USA, January 2004.

- "Panel: Core Networking Issues and Protocols for the Internet," National Science Foundation (NSF) Division of Advanced Networking Infrastructure and Research (ANIR) Principal Investigators Workshop, Washington DC, USA, March 2003.
- "Panel: Pricing for Content in the Internet," SPIE ITCom Internet Performance and Control of Network Systems, Boston, Massachusetts, USA, July 2002.
- "The Technology Behind Wireless LANs," Central Coast MIT Enterprise Forum, Santa Barbara, California, USA, March 2002.
- "Lessons Learned in the Digital Classroom," Center for Information and Technology Brown Bag Symposium, Santa Barbara, California, USA, March 2002.
- "The Evolution of Advanced Networking Services: From the ARPAnet to Internet2," California State University--San Luis Obispo CS Centennial Colloquium Series, San Luis Obispo, California, USA, February 2002.
- "Deployment of IP Multicast in Campus Infrastructures," Internet2 Campus Deployment Workshop, Atlanta, Georgia, USA, May 2001.
- "Multicast: Is There Anything Else to Do?," Sprint Research Retreat, Miami, Florida, USA, May 2001.
- "The Evolution of Next-Generation Internet Services and Applications," Government Technology Conference 2001 (GTC) for the Western Region, Sacramento, California, USA, May 2001.
- "I2 Multicast: Not WIDE-scale Deployment, FULL-scale Deployment," Closing Plenary, Internet2 Member Meetings, Washington, D.C., USA, March 2001.
- "Panel: Beyond IP Multicast," Content Delivery Networks (CDN), New York, New York, USA, February 2001.
- "Viable Multicast Pricing & Business Models for Wider-Scale Deployment," Content Delivery Networks (CDN), New York, New York, USA, February 2001.
- "IP Multicast: Modern Protocols, Deployment, and Management," Content Delivery Networks (CDN), New York, New York, USA, February 2001 & San Jose, California, USA, December 2001.
- "Under the Hood of the Internet," Technology 101: Technology for Investors, Center for Entrepreneurship & Engineering Management, November 2000.
- "Understanding Multicast Traffic in the Internet," (1) University of Virginia, (2) University of Maryland, and (3) Columbia University, September 2000.
- "The Bad, The Ugly, and The Good: The Past, Present, and Future of Multicast," Digital Fountain, San Francisco, California, USA, August 2000.
- "Implications of Source-Specific Multicast (SSM) on the Future of Internet Content Delivery," Occam Networks, Santa Barbara, California, USA, August 2000.
- "Introduction to Multicast Routing Protocols," UC-Berkeley Open Mash Multicast Workshop, Berkeley, California, USA, July 2000.

- "Efforts to Understand Traffic and Tree Characteristics," University of Massachusetts--Amherst Colloquia, Amherst, Massachusetts, USA, May 2000.
- "Monitoring Multicast Traffic," Sprint Research Retreat, Half Moon Bay, California, USA, April 2000.
- "What is the Next Generation of Multicast in the Internet?," HRL Laboratories, Malibu, California, USA, January 2000.
- "Mission and Status of the Center for Information Technology and Society (CITS)," Intel Research Council, Portland, Oregon, USA, September 1999.
- "Multicast at a Crossroads," IP Multicast Initiative Summits and Bandwidth Management Workshops, San Francisco, CA, USA, (1) October 1999; (2) February 2000; and (3) June 2000.
- "IP Multicast: Modern Protocols, Deployment, and Management," Networld+Interop: (1) Las Vegas, Nevada, USA--May 2000; (2) Tokyo, JAPAN--June 2000; (3) Atlanta, Georgia, USA--September 2000; (4) Las Vegas, Nevada, USA--May 2001; (5) Las Vegas, Nevada, USA--May 2002.
- "IP Multicast: Practice and Theory" (w/ Steve Deering), Networld+Interop: (1) Las Vegas, Nevada, USA--May 1999; (2) Tokyo, JAPAN--June 1999; and (3) Atlanta, Georgia, USA--September 1999.
- "Internet2 Multicast Testbeds and Applications," Workshop on Protocols for High Speed Networks (PfHSN), Salem, Massachusetts, USA, August 1999.
- "IP Multicast: Protocols for the Intra- and Inter-Domain," Lucent Technologies, Westford, Massachusetts, USA, August 1999.
- "Internet2 Multicast Testbeds and Applications," NASA Workshop: Bridging the Gap, Moffett Field, California, USA, August 1999.
- "The Evolution of Next-Generation Services and Applications in the Internet," Tektronix Distinguished Lecture Series, Portland, Oregon, USA, May 1999.
- "Multicast Applications and Infrastructure in the Next Generation Internet," CENIC 99 Workshop on Achieving Critical Mass for Advanced Applications, Monterey, California, USA, May 1999.
- "Multicast Traffic Monitoring and Analysis Work at UCSB" (w/ P. Rajvaidya), Workshop on Internet Statistics and Metrics Analysis (ISMA), San Diego, California, USA, April 1999.
- "How the Internet Works: Following Bits Around the World," Science Lite, Santa Barbara General Affiliates and Office of Community Relations, California, USA, February 1999.
- "Managing Multicast: Challenges, Tools, and the Future," IP Multicast Initiative Summit, San Jose, California, USA, February 1999.
- "The Future of Multicast Communication and Protocols," Internet Bandwidth Management Summit (iBAND), San Jose, California, USA, November 1998.
- "An Overview of IP Multicast: Applications and Deployment," (1) Workshop on Evaluating IP Multicast as the Solution for Webcasting Real-Time Networked Multimedia Applications, New York, New York, USA, July 1998; and (2) Satellites and the Internet Conference, Washington, D.C., USA, July 1998.

- "IETF Developments in IP Multicast," IP Multicast Initiative Summit, San Jose, California, USA, February 1998.
- "An Introduction to IP Multicast and the Multicast Backbone (MBone)" vBNS Technical Meeting sponsored by the National Center for Network Engineering (NLANR), San Diego, California, USA, February 1998.
- "Using Multicast Communication to Deliver WWW Pages" Computer Communications Workshop (CCW '97), Phoenix, Arizona, USA, September 1997.

G. Research Funding

- K. Almeroth, "Packet Scheduling Using IP Embedded Transport Instrumentation," Cisco Systems Inc., $100,000, 3/1/13-8/31/14.
- K. Almeroth, E. Belding and S.J. Lee, "GOALI: Maximizing Available Bandwidth in Next Generation WLANs", National Science Foundation (NSF), $101,088, 10/1/13-9/30/14.
- K. Almeroth and E. Belding, "GOALI: Intelligent Channel Management in 802.11n Networks," National Science Foundation (NSF), $51,000, 10/1/10-9/30/11.
- B. Zhao, K. Almeroth, H. Zheng, and E. Belding, "NeTS: Medium: Airlab: Distributed Infrastructure for Wireless Measurements," National Science Foundation (NSF), $700,000, 9/1/09-8/13/13.
- K. Almeroth, E. Belding and T. Hollerer, "NeTS-WN: Wireless Network Health: Real-Time Diagnosis, Adaptation, and Management," National Science Foundation (NSF), $600,000, 10/1/07-9/30/10.
- K. Almeroth, "Next-Generation Service Engineering in Internet2," University Consortium for Advanced Internet Development (UCAID), $1,254,000, 7/1/04-6/30/09 (reviewed and renewed each year).
- B. Manjunath, K. Almeroth, F. Bullo, J. Hespanha, T. Hollerer, C. Krintz, U. Madhow, K. Rose, A. Singh, and M. Turk, "Large-Scale Multimodal Wireless Sensor Network," Office of Naval Research Defense University Research Instrumentation Program (DURIP), $655,174, 4/14/08-4/14/09.
- K. Almeroth and E. Belding, "Improving Robustness in Evolving Wireless Infrastructures," Intel Corporation, $135,000, 7/1/06-6/30/09 (reviewed and renewed for second and third year).
- K. Almeroth and K. Sarac, "Bridging Support in Mixed Deployment Multicast Environments," Cisco Systems Inc., $100,000, 9/1/07-8/31/08.
- K. Sarac and K. Almeroth, "Building the Final Piece in One-to-Many Content Distribution," Cisco Systems Inc., $95,000, 9/1/06-8/31/07.
- E. Belding, K. Almeroth and J. Gibson, "Real-Time Communication Support in a Ubiquitous Next-Generation Internet," National Science Foundation (NSF), $900,000, 10/1/04-9/30/07.
- K. Almeroth and K. Sarac, "Improving the Robustness of Multicast in the Internet," Cisco Systems Inc., $80,000, 9/1/04-8/31/05.

- R. Mayer, B. Bimber, K. Almeroth and D. Chun, "Assessing the Pedagogical Implications of Technology in College Courses," Mellon Foundation, $350,000, 7/1/04-6/30/07.

- B. Bimber, A. Flanagin and C. Stol, "Technological Change and Collective Association: Changing Relationships Among Technology, Organizations, Society and the Citizenry," National Science Foundation (NSF), $329,175, 7/1/04-6/30/07.

- K. Almeroth and B. Bimber, "Plagiarism Detection Techniques and Software," UCSB Instructional Development, $22,000, 7/1/04-6/30/05.

- K. Almeroth, "Student Travel Support for the 14th International Workshop on Network and Operating Systems Support for Digital Audio and Video (NOSSDAV)," National Science Foundation (NSF), $10,000, 5/1/04-8/31/04.

- K. Almeroth, "An Automated Indexing System for Remote, Archived Presentations," QAD Inc., $25,000, 5/1/04-6/30/05.

- K. Almeroth and M. Turk, "A Remote Teaching Assistant Support System," Microsoft, $40,000, 1/1/04-6/30/05.

- K. Almeroth, "Supporting Multicast Service Functionality in Helix," Real Networks, $30,000, 9/1/03-6 /30/04.

- K. Almeroth and E. Belding, "Service Discovery in Mobile Networks," Nokia Summer Research Grant (U. Mohan), $10,240, 7/1/03-9/30/03.

- K. Almeroth, D. Zappala, "Building a Global Multicast Service," Cisco Systems Inc., $100,000, 1/1/03-6/30/04.

- K. Almeroth, "Developing A Dynamic Protocol for Candidate Access Router Discovery," Nokia Graduate Student Fellowship (R. Chalmers), $26,110, 9/01/02-6/30/03.

- B. Bimber and K. Almeroth, "The Role of Collaborative Groupware in Organizations," Toole Family Foundation, $182,500 ($20,000 cash plus $162,500 in software), 9/1/02-8/30/07.

- B. Manjunath, et al., "Digital Multimedia: Graduate Training Program in Interactive Digital Multimedia," National Science Foundation (NSF), $2,629,373, 4/1/02-3/31/07.

- J. Green, K. Almeroth, et al., "Inquiry in the Online Context: Learning from the Past, Informing the Future," UCSB Research Across Disciplines, $10,000, 9/1/01-8/31/02.

- K. Almeroth, "Monitoring and Maintaining the Global Multicast Infrastructure," Cisco Systems Inc., $54,600, 7/1/01-6/30/02.

- R. Kemmerer, K. Almeroth, et al., "Hi-DRA High-speed, Wide-area Network Detection, Response, and Analysis," Department of Defense (DoD), $4,283,500, 5/1/01-4/30/06.

- A. Singh, K. Almeroth, et al., "Digital Campus: Scalable Information Services on a Campus-wide Wireless Network," National Science Foundation (NSF), 1,450,000, 9/15/00-12/31/04.

- K. Almeroth, "Visualizing the Global Multicast Infrastructure," UC MICRO w/ Cisco Systems Inc., $85,438, 7/1/00-6/30/02.

- H. Lee, K. Almeroth, et al., "Dynamic Sensing Systems," International Telemetering Foundation, $260,000, 07/01/00-06/30/04.
- B. Bimber and K. Almeroth, "Funding for the Center on Information Technology and Society," $250,000 from Dialogic (an Intel Company) and $250,000 from Canadian Pacific.
- K. Almeroth, "CAREER: From Protocol Support to Applications: Elevating Multicast to a Ubiquitous Network Service," National Science Foundation (NSF), $200,000, 9/1/00-8/31/04.
- K. Almeroth, "Characterizing Multicast Use and Efficiency in the Inter-Domain," Sprint Advanced Technology Laboratories, $62,500, 3/1/00-6/30/01.
- K. Almeroth, "Producing the Next Generation of Multicast Monitoring and Management Protocols and Tools," UC MICRO w/ Cisco Systems Inc., $124,500, 7/1/99 - 6/30/01.
- K. Almeroth, "Utilizing Satellite Links in the Provision of an Inter-Wide Multicast Service," HRL Laboratories, $20,000, 7/1/99 - 6/30/00.
- T. Smith, K. Almeroth, et al., "Alexandria Digital Earth Prototype," National Science Foundation, $5,400,000, 4/1/99-3/31/04.
- V. Vesna, K. Almeroth, et al., "Online Public Spaces: Multidisciplinary Explorations in Multi-User Environments (OPS:MEME), Phase II," UCSB Research Across Disciplines, $50,000, 9/1/98-8/31/99.
- K. Almeroth, "Techniques and Analysis for the Provision of Multicast Route Management," UC MICRO w/ Cisco Systems Inc., $97,610, 7/1/98 - 6/30/00.
- K. Almeroth, "Capturing and Modeling Multicast Group Membership in the Multicast Backbone (MBone)," UC MICRO w/ Hughes Research Labs, $19,146, 7/1/98 - 12/31/99.
- K. Almeroth, "Building a Content Server for the Next Generation Digital Classroom," UCSB Faculty Research Grant, $5,000, 7/1/98-6/31/99.

H. Research Honors and Awards

- IEEE Fellow Status, 2013
- Finalist for Best Paper Award, IEEE Conference on Sensor and Ad Hoc Communications and Networks (SECON), June 2008
- Best Paper Award, Passive and Active Measurement (PAM) Conference, April 2007
- Outstanding Paper Award, World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED MEDIA), June 2006
- IEEE Senior Member Status, 2003
- Finalist for Best Student Paper Award, ACM Multimedia, December 2002
- Outstanding Paper Award, World Conference on Educational Multimedia, Hypermedia & Telecommunications (ED MEDIA), June 2002
- Computing Research Association (CRA) Digital Government Fellowship, 2001
- National Science Foundation CAREER Award, 2000
- Best Paper Award, 7th International World Wide Web Conference, April 1998

III. Service

A. Professional Activities

1. Society Memberships

Member, Association for Computing Machinery (ACM): 1993-present
Member, ACM Special Interest Group on Communications (SIGComm): 1993-present
Fellow, Institute of Electrical and Electronics Engineers (IEEE): 1993-present
Member, IEEE Communications Society (IEEE ComSoc): 1993-present
Member, American Society for Engineering Education (ASEE): 2003-2006

2. Review Work for Technical Journals and Publishers

NSF CISE research proposals, IEEE/ACM Transactions on Networking, IEEE/ACM Transactions on Computers, IEEE/ACM Transactions on Communications, IEEE Transactions on Circuits and Systems for Video Technology, IEEE Transactions on Parallel and Distributed Systems, IEEE Transactions on Multimedia, IEEE Communications, IEEE Communications Letters, IEEE Network, IEEE Internet Computing, IEEE Multimedia, IEEE Aerospace & Electronics Systems Magazine, ACM Transactions on Internet Technology, ACM Transactions on Multimedia Computing, Communications and Applications, ACM Computing Surveys, ACM Computer Communications Review, ACM Computeres in Entertainment, ACM/Springer Multimedia Systems Journal, AACE Journal of Interactive Learning (JILR), International Journal of Computer Mathematics, Journal of Communications and Networks, Journal of Parallel and Distributed Computing, Journal of Network and Systems Management, Journal of High Speed Networking, Journal of Communications and Networks, Journal on Selected Areas in Communications, Journal of Wireless Personal Communications, Personal Mobile Communications, Annals of Telecommunications, International Journal of Wireless and Mobile Computing, Pervasive and Mobile Computing (PMC), Wireless Networks Journal, Computer Networks Journal, Cluster Computing, Computer Communications, Mobile Computing and Communications Review, Performance Evaluation, Software--Practice & Experience, Information Processing Letters, ACM Sigcomm, ACM Multimedia, ACM Network and System Support for Digital Audio and Video Workshop (NOSSDAV), ACM Sigcomm Workshop on the Economics of Peer-to-Peer Systems (P2PEcon), ACM Sigcomm Workshop on Challenged Networks (CHANTS), IEEE Infocom, IEEE Globecom, IEEE Global Internet (GI) Symposium, IEEE Globecom Automatic Internet Symposium, IEEE Globecom Internet Services and Enabling Technologies (IS&ET) Symposium, IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM), IEEE International Conference on Network Protocols (ICNP), IEEE Conference on Sensor and Ad Hoc Communications and Networks (SECON), IEEE International Conference on Multimedia and Exposition (ICME), IEEE International Conference on Communications (ICC), IEEE International Conference on Parallel and Distributed Systems (ICPADS) IEEE International Symposium on High-Performance Distributed Computing (HPDC), IEEE International Conference on Distributed Computing Systems (ICDCS), IEEE International Workshop on Quality of Service (IWQoS),

IEEE/IFIP Network Operations and Management Symposium (NOMS), IFIP/IEEE International Symposium on Integrated Network Management (IM), IFIP/IEEE International Conference on Management of Multimedia Networks and Services (MMNS), IEEE Aerospace & Electronics Systems Magazine, SPIE Conference on Multimedia Computing and Networking (MMCN), IFIP Networking, IASTED International Conference on Information Systems and Databases (ISD), IASTED International Conference on Communications, Internet, and Information Technology, IASTED International Conference on Internet and Multimedia Systems and Applications (IMSA), IASTED International Conference on European Internet and Multimedia Systems and Applications (EuroIMSA), IASTED International Conference on Communications and Computer Networks (CCN), IASTED International Conference on Software Engineering and Applications (SEA), International Conference on Computer and Information Science (ICIS), International Association for Development of the Information Society (IADIS) International Conference on the WWW/Internet, Workshop on Network Group Communication (NGC), International Conference on Next Generation Communication (CoNEXT), International Conference on Parallel Processing (ICPP), International Conference on Computer Communications and Networks (IC3N), International Workshop on Hot Topics in Peer-to-Peer Systems (Hot-P2P), International Workshop on Wireless Network Measurements (WiNMee), International Workshop on Incentive-Based Computing (IBC), International Workshop on Multi-hop Ad Hoc Networks (REALMAN), International Workshop on Broadband Wireless Multimedia: Algorithms, Architectures and Applications (BroadWIM), International Packet Video (PV) Workshop, High Performance Networking Conference (HPN), International Parallel Processing Symposium (IPPS), International Symposium on Innovation in Information & Communication Technology (ISIICT), Workshop on Coordinated Quality of Service in Distributed Systems (COQODS), Pearson Education (Cisco Press) Publishers, Macmillan Technical Publishing, and Prentice Hall Publishers.

3. Conference Committee Activities

Journal/Magazine Editorial Board

IEEE Transactions on Mobile Computing (TMC): 2006-2011, 2017-2020 (Associate Editor-in-Chief)
IEEE Networking Letters: 2018-2021
IEEE Transactions on Network and Service Management (TNSM): 2015-2021
Journal of Network and Systems Management (JNSM): 2011-present
IEEE/ACM Transactions on Networking (ToN): 2003-2009, 2013-2017
ACM Computers in Entertainment: 2002-2015
IEEE Network: 1999-2012
AACE Journal of Interactive Learning Research (JILR): 2003-2012
IEEE Transactions on Mobile Computing (TMC): 2006-2011
ACM Computer Communications Review (CCR): 2006-2010

Journal/Magazine Guest Editorship

IEEE Journal on Selected Areas in Communications (JSAC) Special Issue on "Delay and Disruption Tolerant Wireless Communication", June 2008
Computer Communications Special Issue on "Monitoring and Measuring IP Networks", Summer 2005
Computer Communications Special Issue on "Integrating Multicast into the Internet", March 2001

Conference/Workshop Steering Committee

IEEE International Conference on Network Protocols (ICNP): 2007-present
ACM Sigcomm Workshop on Challenged Networks (CHANTS): 2006-present
IEEE Global Internet (GI) Symposium: 2005-2013, 2018-present
International Workshop on Network and Operating System Support for Digital Audio and Video (NOSSDAV): 2001-2020, 2005-2011 (chair), 2012-2020 (co-chair)
IFIP/IEEE International Conference on Management of Multimedia Networks and Services (MMNS): 2005-2009

Conference/Workshop Chair

International Conference on Communication Systems and Networks (COMSNETS): 2014 (co-chair)
ACM International Conference on Next Generation Communication (CoNext): 2013 (co-chair)
ACM RecSys News Recommender Systems (NRS) Workshop and Challange: 2013 (co-chair)
ACM Sigcomm Workshop on Challenged Networks (CHANTS): 2006 (co-chair)
IEEE International Conference on Network Protocols (ICNP): 2003 (co-chair), 2006
International Workshop on Wireless Network Measurements (WiNMee): 2006 (co-chair)
IFIP/IEEE International Conference on Management of Multimedia Networks and Services (MMNS): 2002 (co-chair)
International Workshop on Network and Operating System Support for Digital Audio and Video (NOSSDAV): 2002 (co-chair), 2003 (co-chair)
IEEE Global Internet (GI) Symposium: 2001 (co-chair), 2018 (co-chair)
International Workshop on Networked Group Communication (NGC): 2000 (co-chair)

Program Chair

International Conference on Computer Communication and Networks (ICCCN): 2015 (Track co-chair) International Conference on Communication Systems and Networks (COMSNETS): 2010
IEEE International Conference on Network Protocols (ICNP): 2008 (co-chair)
IEEE Conference on Sensor and Ad Hoc Communications and Networks (SECON): 2007 (co-chair)
IFIP Networking: 2005 (co-chair)

Posters/Demonstrations Chair

ACM Sigcomm: 2012 (co-chair)

Student Travel Grants Chair

ACM Sigcomm: 2010 (co-chair)

Publicity Chair

IFIP/IEEE International Conference on Management of Multimedia Networks and Services (MMNS): 2004 (co-chair)

Keynote Chair

IEEE Infocom: 2005 (co-chair)

Local Arrangements Chair

Internet2 "Field of Dreams" Workshop: 2000

Tutorial Chair

ACM Multimedia: 2000
IEEE International Conference on Network Protocols (ICNP): 1999

Panel/Session Organizer

NSF ANIR PI 2003 Panel on "Core Networking Issues and Protocols for the Internet"
CCW 2001 Session on "Multicast/Peer-to-Peer Networking"
NOSSDAV 2001 Panel on "Multimedia After a Decade of Research"
NGC 2000 Panel on "Multicast Pricing"

Technical Program Committee

IEEE International Conference on Network Protocols (ICNP): 1999, 2000, 2001, 2003, 2004, 2005, 2006, 2007, 2008, 2009 (Area Chair), 2010 (Area Chair), 2011 (Area Chair), 2012 (Area Chair), 2013, 2014 (Area Chair), 2015 (Area Chair), 2016 (Area Chair), 2017 (Area Chair), 2018 (Area Chair), 2019 (Area Chair), 2020 (Area Chair), 2021 (Area Chair)
International Workshop on Network and Operating System Support for Digital Audio and Video (NOSSDAV): 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019
ACM Multimedia (MM): 2001, 2003, 2004, 2005 (short paper), 2006, 2007, 2008, 2008 (short paper), 2010, 2011, 2012, 2013, 2015, 2016, 2017, 2018, 2019
IEEE Conference on Sensor and Ad Hoc Communications and Networks (SECON): 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011 (Area Chair), 2012 (Area Chair), 2013, 2014 (Area Chair), 2015, 2016 (Area Chair), 2017, 2018, 2019
IEEE/IFIP Network Operations and Management Symposium (NOMS): 2004, 2006, 2010
IEEE Infocom: 2004, 2005, 2006, 2008, 2009, 2010 (Area Chair), 2011 (Area Chair), 2012 (Area Chair)
IFIP Networking: 2004, 2005, 2006, 2007, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2022
IEEE International Conference on Communications (ICC) Next Generation Networking and Internet Symposium (NGNI): 2018, 2019
ACM Workshop on Mobile Video (MoVid): 2014, 2015, 2016, 2017
ACM Student Research Competition (SRC) Grand Finals: 2014
Mobile and Social Computing for Collaborative Interactions (MSC): 2014
IEEE Conference on Communications and Network Security (CNS): 2013
IEEE International Symposium on a World of Wireless, Mobile and Multimedia Networks (WoWMoM): 2005, 2006, 2007, 2008, 2009, 2010
ACM Sigcomm Workshop on Challenged Networks (CHANTS): 2006, 2008, 2009, 2010, 2011, 2012, 2016, 2017, 2018, 2019
IEEE International Conference on Distributed Computing Systems (ICDCS): 2006, 2010, 2011, 2012, 2013
International Workshop on Wireless Network Measurements (WiNMee): 2006, 2008, 2010
ACM Sigcomm: 2008 (poster), 2010
IEEE International Conference on Computer Communication and Networks (IC3N): 2008, 2009, 2010, 2011, 2012
International Conference on Communication Systems and Networks (COMSNETS): 2009,

2010, 2011, 2012, 2013
International Conference on Sensor Networks (SENSORNETS): 2012
International Workshop on Social and Mobile Computing for Collaborative Environments (SOMOCO): 2012
Workshop on Scenarios for Network Evaluation Studies (SCENES): 2009, 2010, 2011
ACM Multimedia Systems (MMSys): 2010, 2011, 2012, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022
IEEE Internation Symposium on Multimedia (ISM): 2016
IEEE International Conference on Pervasive Computing and Communications (PerCom): 2010
IEEE Wireless Communications and Networking Conference (WCNC): 2010, 2011
ACM International Symposium on Mobility Management and Wireless Access (MobiWac): 2010, 2011
International Conference on Computing, Networking and Communications, Internet Services and Applications Symposium (ICNC-ISA): 2012, 2013
IEEE WoWMoM Workshop on Hot Topics in Mesh Networking (HotMesh): 2010, 2011, 2012, 2013
IEEE Workshop on Pervasive Group Communication (PerGroup): 2010
ACM International Conference on Next Generation Communication (CoNEXT): 2005, 2006, 2007, 2009, 2012
IEEE International Conference on Broadband Communications, Networks, and Systems (BroadNets) Wireless Communications, Networks and Systems Symposium: 2007, 2008, 2009
IEEE International Conference on Broadband Communications, Networks, and Systems (BroadNets) Internet Technologies Symposium: 2007, 2008, 2009
International Workshop on Mobile and Networking Technologies for Social Applications (MONET): 2008, 2009
Extreme Workshop on Communication-The Midnight Sun Expedition (ExtremeCom): 2009
IEEE International Workshop on Cooperation in Pervasive Environments (CoPE): 2009
International Workshop on the Network of the Future (FutureNet): 2009, 2010, 2011, 2012
IEEE International Conference on Multimedia and Exposition (ICME): 2010
SPIE Conference on Multimedia Computing and Networking (MMCN): 2004, 2008
ACM Sigcomm Workshop on the Economics of Networks, Systems, and Computation (NetEcon): 2008
IEEE International Conference on Communications (ICC): 2008
IEEE International Conference on Mobile Ad-hoc and Sensor Systems (MASS): 2008
IFIP/IEEE International Symposium on Integrated Network Management (IM): 2005, 2007
Global Internet (GI) Symposium: 2001, 2002, 2004, 2006, 2007, 2022, 2023
IEEE/ACM International Conference on High Performance Computing (HiPC): 2007
ACM International Symposium on Mobile Ad Hoc Networking and Computing (MobiHoc): 2007
IEEE Workshop on Embedded Systems for Real-Time Multimedia (ESTIMedia): 2007
IEEE/IFIP Wireless On Demand Network Systems and Services (WONS): 2007
IFIP/IEEE International Conference on Management of Multimedia Networks and Services (MMNS): 2001, 2002, 2003, 2004, 2005, 2006
IASTED International Conference on European Internet and Multimedia Systems and Applications (EuroIMSA): 2004, 2006
IEEE International Conference on Parallel and Distributed Systems (ICPADS): 2005, 2006
IEEE Globecom Internet Services and Enabling Technologies (IS&ET) Symposium: 2006

International Workshop on Incentive-Based Computing (IBC): 2006
IEEE International Workshop on Quality of Service (IWQoS): 2006, 2014, 2015
International Workshop on Multi-hop Ad Hoc Networks (REALMAN): 2006
IEEE Globecom Automatic Internet Symposium: 2005
ACM Sigcomm Workshop on the Economics of Peer-to-Peer Systems (P2PEcon): 2005
International Conference on Parallel Processing (ICPP): 2001, 2003, 2004
International Packet Video (PV) Workshop: 2002, 2003, 2004
IEEE International Symposium on High-Performance Distributed Computing (HPDC): 2004
ACM Sigcomm: 2004 (poster)
International Workshop on Broadband Wireless Multimedia: Algorithms, Architectures and Applications (BroadWIM): 2004
International Symposium on Innovation in Information & Communication Technology (ISIICT): 2004
Workshop on Coordinated Quality of Service in Distributed Systems (COQODS): 2004
IASTED International Conference on Networks and Communication Systems (NCS): 2004
IASTED International Conference on Communications, Internet, and Information Technology (CIIT): 2004
IASTED International Conference on Internet and Multimedia Systems and Applications (IMSA): 2003, 2004
International Workshop on Networked Group Communication (NGC): 1999, 2000, 2001, 2002, 2003
International Association for Development of the Information Society (IADIS)
International Conference on the WWW/Internet: 2003
International Conference on Computer and Information Science (ICIS): 2003
Human.Society@Internet: 2003
IASTED International Conference on Communications and Computer Networks (CCN): 2002
The Content Delivery Networks (CDN) Event: 2001
IP Multicast Initiative Summit: 1998, 1999, 2000
Corporation for Education Network Initiatives in California (CENIC): 1999
Internet Bandwidth Management Summit (iBAND): 1998, 1999

B. Technical Activities

1. Working Groups

Internet2 Working Group on Multicast, Chair: 1998-2005
IEEE Communications Society Internet Technical Committee (ITC), Conference Coordinator: 2000-2004
IETF Multicast Directorate (MADDOGS), Member: 1999-2001
IASTED Technical Committee on the Web, Internet and Multimedia, Member: 2002-2005
Internet Engineering Task Force (IETF), various working groups: 1995-present

2. Meeting Support Work

Internet Engineering Task Force MBone broadcasts: 1995-2005
Conference MBone broadcasts: Sigcomm '99, and '00
Interop+Networld Network Operations Center (NOC) Team Member: 1995-1997
ACM Multimedia technical staff: 1994

C. University of California Committees

1. Department of Computer Science Committees

Public Relations: 2005-2006 (chair 2005-2006), 2009-2011 (chair 2009-2011)
Strategic Planning: 2000-2002, 2003-2006, 2009-2011
Undergraduate Advising and Affairs: 2006-2007, 2014-2015
Vice Chair: 2000-2005
Graduate Admissions: 2000-2005 (chair 2000-2005), 2011-2012
Graduate Affairs: 2000-2005 (co-chair 2000-2005)
Teaching Administration: 2000-2005
Facilities: 1997-2001 (chair 1999-2000), 2006-2007
External Relations: 1999-2002
Computer Engineering Public Relations: 2011-2012
Computer Engineering Awards: 2011-2012
Computer Engineering Administration/Recruiting: 1998-2001
Computer Engineering Lab and Computer Support: 1998-2001
Faculty Recruiting: 1999-2002
Graduate Advising: 1998-1999, 2000-2005

2. University Committees

Member, Campus Budget and Planning: 2013-2015
Faculty, Cognitive Science Program: 2006-2020
Faculty, Technology Management Program (TMP): 2003-2014
Faculty, Media Arts and Technology (MAT) Program: 1998-2014
Faculty, Computer Engineering Degree Program: 1998-2020
Steering Committee, Center for Information Technology and Society (CITS): 2012-2020
Associate Director, Center for Information Technology and Society (CITS): 1999-2012
Member, Campus Committee on Committees: 2010-2013
Member, Campus Income and Recharge Committee: 2010-2013
Member, College of Engineering Executive Committee: 2010-2012 (chair 2011-2012), 2014-2015 (chair 2014-2015)
Member, Distinguished Teaching Award Committee: 2009, 2010, 2011
Member, Campus Classroom Design and Renovation Committee: 2003-2010
Member, ISBER Advisory Committee: 2008-2011
Member, Fulbright Campus Review Committee: 2007
Member, Faculty Outreach Grant Program Review Committee: 2007
Executive Vice Chancellor's Information Technology Fee Committee: 2005-2006
Council on Research and Instructional Resources: 2003-2006
Executive Vice Chancellor's Working Group on Graduate Diversity: 2004-2005
Member, Engineering Pavillion Planning Committee: 2003-2005

Information Technology Board: 2001-2004
Executive Committee, Center for Entrepreneurship & Engineering Management (CEEM): 2001-2004

3. System Wide Committees

UCSB Representative to the Committee on Information Technology and Telecommunications Policy (ITTP): 2003-2005
UCSB Representative to the Executive Committee, Digital Media Innovation (DiMI): 1998-2003

D. Georgia Tech Committees and Service (while a graduate student)

Graduate Student Body President: 1994-1995
Georgia Tech Executive Board: 1994-1995
Georgia Tech Alumni Association Executive Committee: 1994-1995
Dean of Students National Search Committee: 1995
Institute Strategic Planning Committee: 1994-1996

Cases in last 4 years I have been deposed or testified:

- Depositions in Inter Partes Review of U.S. Patent Nos. 8,886,739 (IPR2018-00200); 9,306,885 (IPR2018-00312); 9,315,155 (IPR2018-00369); 9,306,886 (IPR2018-00397); 8,935,351 (IPR2018-00404); 9,338,111 (IPR2018-00408); 9,413,711 (IPR2018-00416 and IPR2018-00439); 9,313,157 (IPRs018-00455); and 9,313,156 (IPR2018-00458) [Snap, Inc. v. Vaporstream, Inc.]. Finished 04/2019.
- Depositions in Rmail Limited, et al. v. Amazon.com, Inc.; Docusign, Inc.; Right Signature, LLC, et al.; and Adobe Systems Inc., et al. (2:10-cv-258-JRG, 2:11-cv-299-JRG, 2:11-cv-300-JRG, 2:11-cv-325-JRG, E. D. Tex.). Finished 06/2019.
- Depositions and trial testimony in Certain Wireless Mesh Networking Products and Related Components Thereof (US ITC Inv. No. 337-TA-1131) [SIPCO, LLC v. Emerson Electric Co]. Finished 09/2019.
- A deposition in Packet Intelligence v. Nokia of America Corporation (2:18-cv-382-JRG, E. D. Tex.). Finished 09/2019.
- A deposition in TQ Delta, LLC v. Zyxel Communications, Inc. (13-cv-2013-RGA, D. Del.). Finished 11/2019.
- A deposition and trial testimony in Implicit, LLC v. NetScout Systems, Inc. and Sandvine Corporation (2:18-cv-0053-JRG and 2::18-cv-0054-JRG, E. D. Tex.). Finished 12/2019.
- A deposition and trial testimony in Sony Music Entertainment, et al. v. Cox Communications, Inc. et al. (1:18-cv-00950-LO-JFA, E. D. Va.). Finished 12/2019.
- Depositions in Inter Partes Review of U.S. Patent Nos. 9,369,741 (IPR2019-00231) and 9,621,956 (IPR201-00281) [Comcast Cable Communications, LLC v. Rovi Guides Inc.]. Finished 01/2020.
- A deposition and trial testimony in Certain Digital Video Receivers, Broadband Gateways, and Related Hardware and Software Components (US ITC Inv. No. 337-TA-1158) [Rovi Guides, Inc. v. Comcast Cable Communications, LLC]. Finished 01/2020.
- A deposition in Innovation Sciences, LLC v. Resideo Technologies, Inc. (4:18-cv-00475-ALM, E. D. Tex.). Finished 02/2020.
- Depositions and a claim construction tutorial in Blackberry Limited v. Facebook, Inc. and Snap, Inc. (2:18-cv-01844 GW(KSx) and 2:18-cv-02693-GW(KSx), C. D. Cal.). Finished 03/2020.
- A deposition in Inter Partes Review of U.S. Patent Nos. 9,912,983 (IPR2019-01306) [Resideo Technologies, Inc. v. Innovation Sciences, LLC]. Finished 05/2020.
- A deposition in Sprint Communications Company LP v. Charter Communications, Inc. et al. (17-1734-RGA, D. Del.). Finished 06/2020.
- Depositions in Inter Partes Review of U.S. Patent Nos. 9,369,741 (IPR2019-00231), 9,621,956 (IPR2019-00281), and 9,118,948 (IPR2019-01421) [Comcast Cable Communications, LLC v. Rovi Guides Inc.]. Finished 07/2020.
- Depositions and claim construction tutorial in Netfuel, Inc. v. Cisco Systems, Inc. (5:18-cv-2352-EJD, N. D. Cal). Finished 08/2020.

- A deposition in Inter Partes Review of U.S. Patent No. 9,663,659 (IPR2019-00992) [Cisco Systems, Inc. v. NetFuel, Inc.]. Finished 09/2020.
- A deposition in Monarch Network Solutions, LLC v. Cisco Systems, Inc. (2:20-cv-00015-JRG, E. D. Tex.). Finished 09/2020.
- A deposition in Finjan, Inc. v. Rapid7, Inc. (1:18-cv-01519-MN, D. Del.). Finished 09/2020.
- A deposition in Finjan, Inc. v. SonicWall, Inc. (5:17-cv-04467-BLF-HRL, N. D. Cal.). Finished 10/2020.
- Depositions and trial testimony in TQ Delta, LLC v. 2Wire, Inc. (1:13-cv-01835-RGA, D. Del.). Finished 11/2020.
- A deposition in Linksmart Wireless Technology, LLC v. Gogo, LLC and Panasonic Avionics Corp (8:18-cv-00654-JAK-JDE and 8:18-cv-00662-JAK-JDE). Finished 12/2020.
- A deposition and trial testimony in Certain Audio Players and Controllers, Components, Thereof and Products Containing the Same (ITC Inv. No. 337-TA-1191) [Sonos, Inc. v. Google LLC and Alphabet, Inc.]. Finished 02/2021.
- A deposition in Finjan, Inc. v. Cisco Systems, Inc. (5:17-cv-00072-BLF-SVK, N. D. Cal). Finished 02/2021.
- A deposition and trial testimony in Gigamon, Inc. v. Apcon, Inc. (2:19-cv-300-JRG, E. D. Tex.). Finished 04/2021.
- A deposition in Certain IP Camera Systems including Video Doorbells and Components Thereof (US ITC Inv. No. 337-TA-1242) [SkyBell Technologies, Inc., SB IP Holdings, LLC, and Eyetalk365, LLC v. SimpliSafe, Inc., Arlo Technologies, Inc., and Vivint Smart Home, Inc.]. Finished 09/2021.
- A deposition in Warner Records, Inc. et al. v. Charter Communications, Inc. (19-cv-00874-RBJ-MEH, D. Colo.). Finished 10/2021.
- A deposition and trial testimony in VideoShare, LLC v. Google LLC (6:19-cv-00663-ADA, W. D. Tex.). Finished 11/2021.
- A deposition in The Chamberlain Group, LLC v. Overhead Door Corp. (2:21-cv-0084, E. D. Tex.). Finished 12/2021.
- Depositions in Contour IP Holding, LLC v. GoPro, Inc. (17-cv-04738-WHO, N. D. Cal.). Finished 12/2021.
- A deposition in Chewy, Inc. v. International Business Machines Corporation (1:21-cv-1319-JSR, S. D.N.Y.). Finished 02/2022.
- A deposition in Flexiworld Technologies, Inc. v. Roku, Inc. (6:20-cv-00819-ADA, W. D. Tex.). Finished 02/2022.
- A deposition in Proven Networks, LLC v. NetApp, Inc. (6:20-cv-00369-ADA, W. D. Tex.). Finished 03/2022.

- Trial testimony in Two Way Media LTD v. Telefonica (517/2017-X, Barcelona, Spain). Finished 05/2022.
- A deposition and claim construction hearing testimony in Peloton Interactive, Inc. v. Icon Health and Fitness, Inc. (1:20-cv-00662-RGA, D. Del.). Finished 05/2022.
- Depositions in Icon Health and Fitness, Inc. v. Peloton Interactive, Inc. (20-1386-RGA, D. Del.). Finished 05/2022.
- A deposition and hearing testimony in UMG Recordings, Inc., et al. v. Bright House Networks, LLC (8:19-cv-00710-MSS-TGW, M. D. Fla.). Finished 05/2022.
- A deposition in Inter Partes Review of U.S. Patent Nos. 9,860,198 (IPR2021-00882) and 10,728,192 (IPR2021-00883) [Meta Platforms, Inc. v. Wrinkl Inc.]. Finished 06/2022.
- Depositions in Inter Partes Review of U.S. Patent Nos. 8,166,081 (IPR2021-01267), 8,688,028 (IPR2021-01303), 8,903,307 (IPR2021-01305), and 8,200,203 (IPR2021-01371) [Hyundai Motor America v. StratosAudio, Inc.]. Finished 08/2022.
- A deposition and trial testimony in Shopify, Inc. v. Express Mobile, Inc. (1:19-cv-00439-RGA, D. Del.). Finished 08/2022.
- Depositions in Inter Partes Review of U.S. Patent Nos. 9,291,475 (IPR2022-00708 and IPR2023-00031); 9,602,608 (IPR2022-00709); 7,484,008 (IPR2022-00857); and 6,832,283 (IPR2022-0970) [Toyota Motor Corp. and American Honda Motor Co, Inc. v. Intellectual Ventures II LLC]. Finished 02/2023.
- A deposition and trial testimony in Express Mobile, Inc. v. GoDaddy.com, LLC (1:19-cv-01937-RGA, D. Del.). Finished 03/2023.
- Depositions in TQ Delta, LLC v. AdTran, Inc. (14-cv-954-RGA, 15-cv-121-RGA, D. Del).
- A deposition in Motorola Solutions, Inc. v. Hytera Communications Corp. LTD (1:17-cv-01972, N. D. Ill.)
- Depositions and trial testimony in Luminati Networks Ltd. v. UAB Tesonet and UAB Metacluster LT (2:18-cv-00299-JRG, E. D. Tex.); Luminati Networks Ltd. v. Teso LT, UAB; Oxysales, UAB; and Metacluster LT, UAB, (2:19-cv-00395-JRG, E. D. Tex.); Luminati Networks Ltd. v. Code 200, UAB; Oxysales, UAB; and Metacluster LT, UAB (2:19-cv-00396-JRG, E. D. Tex.); and Bright Data Networks Ltd. v. Tefincom S.A. (2:19-cv-00414-JRG, E. D. Tex.)
- A deposition and trial testimony in Centripetal Networks, Inc. v. Cisco Systems, Inc. (2:18-cv-00094, E. D. Va.).
- Depositions in Personal Audio, LLC v. Google, Inc. (1:17-cv-01751-VAC-CJB, D. Del)
- A deposition in Post-Grant Review of U.S. Patent No. 10,782,951 (PGR2021-00096) and 11,157,256 (PGR2022-00053) [IronSource Ltd. v. Digital Turbine, Inc.].
- A deposition in FirstFace Co, LTD v. Apple, Inc (3:18-cv-02245-JD, N. D. Cal.).
- A deposition in Touchstream Technologies, Inc. v. Google, LLC (6:21-cv-00569-ADA, W. D. Tex.).

- A deposition in WebRoot, Inc. and Open Text, Inc. v. Trend Micro, Inc. (22-cv-00239-ADA-DTG, W. D. Tex.).
- A deposition in WSOU Investments, LLC v. Cisco Systems, Inc. (6:20-cv-00128-ADA, W. D. Tex.)
- Depositions in Sonos, Inc. v. Google LLC (6:20-cv-881-ADA, W. D. Tex.; 3:20-cv-06754-WHA, N. D. Cal.; and 3:21-cv-07559-WHA, N. D. Cal.)

Appendix B

NEWTON's TELECOM DICTIONARY

The Official Dictionary of Telecommunications Networking and Internet

STAY INFORMED

To be alerted by email to updates and corrections go to **www.cmpbooks.com/newton**

NEWTON's TELECOM DICTIONARY

email: Harry_Newton@HarryNewton.com
personal web site: www.HarryNewton.com
business web site: www.TechnologyInvestor.com

Published by CMP Books
An imprint of CMP Media Inc.
Converging Communications Group
12 West 21 Street
New York, NY 10010

For individual or quantity orders
CMP Books
6600 Silacci Way Gilroy, CA 95020
Tel: 1-800-500-6875 or 1-408-848-5296
Fax:408-848-5784
Email: cmp@rushorder.com
Web:www.cmpbooks.com
Distributed to the book trade in the U.S. and Canada by
Publishers Group West
1700 Fourth St., Berkeley, CA 94710
Phone: 510-528-1444
ISBN Number 1-57820-069-5

February 2001

Seventeenth Edition

Matt Kelsey, Publisher
Christine Kern, Manager
Ray Horak, Managing Editor
Omar Mirabel, Cover Artist
Danel Roldan, Inside Layout Artist

Manufactured in the United States of America
Von Hoffmann Graphics
Owensville, MO 65066

alternate functions. Some carrier telephone equipment designed for ringdown manual operation can be modified with applique to allow for use between points having dial equipment.

APPN Advanced Peer-to-Peer Networking is, according to its creator IBM, a leading-edge distributed networking feature IBM has added to its Systems Network Architecture (SNA). It provides optimized routing of communications between devices. In addition to simplifying the addition of workstations and systems to a network and enabling users to send data and messages to each other faster, APPN is designed to support efficient and transparent sharing of applications in a distributed computing environment. Because APPN permits direct communication between users anywhere on a network, it facilitates the development of client/server computing, in which workstation users anywhere on a network can share processing power, applications and data without regard to where the information is located. Workstations on an APPN network are dynamically defined so they can be relocated easily on the network without extensive re-programming. APPN also allows remote workstations to communicate with each other, without intervention by a central computer. Also, IBM's Advanced Peer-to-Peer Networking software.

APPN End Node An APPN end node is the final destination of user data. The end node cannot function as an intermediate node in an APPN network and cannot perform routing functions. See APPN.

Approved Ground Grounds that meet the requirements of the NEC (National Electrical Code), such as building steel, concrete-encased electrodes, ground rings, and other devices. See AC and Grounding.

AppServer A SCSA term. AppServer defines the software environment that enables voice processing applications to run on any computing platform. AppServer sits on a PC equipped with call processing hardware and allows a remotely hosted application to control the call processing hardware.

APR Annual Percentage Rate. A percentage calculation of a finance charge portion of a financing contact.

APS Automatic Protection Switching. A means of achieving network resiliency through switching devices which automatically switch from a primary circuit to a secondary (usually geographically diverse) circuit. This switching process would take place when the primary circuit fails or when the error rate on the primary line exceeds a set threshold. There are two basic APS architectures in SONET optical fiber networks: 1+1 and 1:N. A 1+1 architecture is characterized by permanent electrical bridging to service and protection equipment, which is placed at both ends of the circuit. At the head end, or transmitting end, the same payload signal is sent over both the primary and the secondary optical circuit. The optical signal is monitored for failures at the tail end independently and identically over both optical circuits. The receiving equipment at the tail end selects either the service channel (primary circuit) or the protection channel (secondary circuit), based on pre-defined switching performance criteria. A 1:N protection switch architecture is one in which any of "N" (i.e., any Number of) service channels (primary circuits) can be bridged to a single optical protection channel (secondary circuit).

APT Asia-Pacific Telecommunity.

AQCB Automated Quote Contract Billing. System used to price non-tariffed products and services.

AR Automatic Recall.

ARA AppleTalk Remote Access. Provides an asynchronous AppleTalk connection to another Macintosh and its network services through a modem. A remote user using ARA can log on to a remote server and mount the volume on his desktop as if he were connected locally.

ARAB Attendant Release Loop. A feature of the PBX console. See Release.

Arabic Numerals Shakespeare was right when he asked, "What's in a name?" The jackrabbit is not a rabbit. It is a hare. A Jerusalem artichoke is not an artichoke; it is a sunflower. Arabic numerals are not Arabic; they were invented in India. India ink (sometimes referred to as "Chinese ink") was not known until recently in either China or India.

ARAM Audio grade DRAM. DRAMS are low cost integrated circuits that are widely used in consumer electronic's products to store digital data.

Aramid Aramid is a synthetic textile material which is lightweight, nonflammable, and highly impact-resistant. Dupont markets it under the trademark Kevlar. In addition to being used in construction of some fiber optic cables to provide tensile strength, aramid fibers are used in bulletproof vests, sailboat sails, and industrial-strength shoelaces. See Tight Buffer Fiber Optic Cables.

Arbitrated Loop Arbitrated loop is a shared, 100 MBps (200 MBps full duplex) architecture. Analogous to Token Ring, multiple devices can be attached to the same loop segment, typically via a loop hub. Up to 126 devices and one fabric (switch) attachment are allowed, although the majority of arbitrated loops are deployed with from four to 30 devices. Since the loop is a shared transport medium, devices must arbitrate for access to the loop before sending data. Fibre Channel provides a superset of commands to provide orderly access and ensure data integrity. A GBIC, or gigabit interface converter, is a removable transceiver and is commonly used in Fibre Channel switches, hubs and host bus adapters. A transceiver converts one form of signaling into another, e.g., fiber optic signals to electrical signals.

Arbitrated Loop Topology A Fibre Channel topology that provides a (FC-AL) low-cost solution to attach multiple communicating ports in a loop. Nodes are linked together in a closed loop. Traffic is managed with a token-acquisition protocol, and only one connection can be maintained within the loop at a time. See Fibre Channel.

Arbitrage The price of gold in London equals the price of gold in New York. If it didn't, traders would step in, buy in one place and sell in another. This process is called arbitrage. There are huge price differences in long distance and international calling from different carriers. In the late 1990s, there was talk of "on-line arbitrage" — whereby I would indicate that I wanted to make a call, and offer that call to on-line traders who would instantly find me a cheap rate.

Arbitration A Fibre Channel term. The process of selecting one respondent from a collection of several candidates that request service concurrently.

ARC Attached Resource Computer, the root name of the local area networks (LAN). It was developed by Datapoint Corporation called ARCNET. It was one of the first LANs. Ethernet and Datapoint's incompetent management killed it. See ARCNET.

ARCH Access Response CHannel. Specified in IS-136, ARCH carries wireless system responses from the cell site to the user terminal equipment. ARCH is a logical subchannel of SPACH (SMS (Short Message Service) point-to-point messaging, Paging, and Access response CHannel), which is a logical channel of the DCCH (Digital Control CHannel), a signaling and control channel which is employed in cellular systems based on TDMA (Time Division Multiple Access). The DCCH operates on a set of frequencies separate from those used to support cellular conversations. See also DCCH, IS-136, SPACH and TDMA.

Archie An Internet term. A corruption of "archive," Archie is a FTP search engine located on several computers around the country. It's sort of a superdirectory to the files on the Internet. If you're looking for a file or even a particular topic, Archie provides its specific location. Veronica, Jughead and WAIS (Wide Area Information Servers) are other tools for searching the huge libraries of information on the Internet. Some companies, such as Hayes, make Archie software which give you a menu driven interface that lets you browse through the various Archie servers on the Internet as though browsing through card catalogs of remote libraries.

Architectural Assemblies Walls, partitions, or other barriers that are not load bearing. In contrast, Architectural Structures are load bearing.

Architectural Freedom An AT&T term for flexibility in locating functions, such as control, storage or processing of information, at any site in or around a network, such as customer premises, central offices or regional service bureaus. Architectural freedom also means the ability to distribute functions among combinations of locations and have them interrelate through a high-throughput, low-delay, transparent network. See also Architecture.

Architectural Structures Walls, floors, floor/ceilings and roof/ceilings that are load bearing. In contrast, Architectural Assemblies are not load bearing.

Architecture The architecture of a system refers to how it is designed and how the components of the system are connected to, and operate with, each other. It covers voice, video, data and text. Architecture also includes the ability of the system to carry narrow, medium and broadband signals. It also includes the ability of the system to grow "seamlessly" (i.e. without too many large jumps in price).

Architecture Police An individual or group within a company that makes sure software and hardware development follows established corporate guidelines. The architecture police tend to rein in creative development efforts.

Archival Readable (and sometimes writable) media. Archival media have defined minimum life-spans over which the information will remain stable (i.e, accurate without degradation).

Archive A backup of a file. An archived file may contain backup copies of programs and files in use or data and materials no longer in use, but perhaps needed for historical or tax purposes. Archive files are kept on paper, on microfilm, on disk, on floppies, etc. They may be kept in compressed or uncompressed form. See Archiver.

Archive Bit A Windows NT (soon to be Windows 2000) term. Backup programs use

A

Typically, cable management covers keeping track of where the cables are (maps are useful), what type and quality the cable is, and what is attached to either end of it. Cable management for corporations is critical, since stringing, laying and snaking of new cable can be inordinately expensive.

Cable Mapping Cable mapping is the task of trying to track every single pair of wire or circuit from beginning to end. You will need to know where all cables reside, not just the circuits that are in use. Cable mapping is critical for any organization — from company to university — which has a lot of cables floating around. Installing more of it — when there are plenty of spare pairs — is stupid and expensive. Thus, the need for cable mapping.

Cable Mile Also known as sheath mile. The measurement, in miles, of fiber optic cable that is deployed. Contrast with fiber mile and route mile.

Cable Modem A cable modem is a small box that connects your PC to the Internet via your local cable TV provider. A cable modem will typically have three connections, one to the coaxial cable wall outlet coming in from your friendly local CATV provider and the other two to connect to your PC and your TV. That PC connection will typically be a standard 10Base-T RJ-45 Ethernet connector, the same connection as you have in your office on your LAN. In essence, a cable modem is a 10 megabit per second Ethernet local area network, in which all the other local cable subscribers are essentially on the same LAN, one end of which is connected to the Internet. Because a cable modem creates a LAN, you have to be careful when using it since all the other local subscribers can "see" your hard disk. As a result, it's important not to allow sharing on your hard disk. Cable modems allow PC users to download information from on-line services at speeds one hundred times faster than today's fastest telephone modems. What actual speed you'll get with your cable modem depends, of course, on a lot of things: how many people are on your "cable LAN" and are presently transmitting or receiving; how fast the connection is from your cable LAN to the Internet; how fast the connections are along the way; how fast the distant server is that you're attached to, etc. etc.
In short, a cable modem is a modem designed for use on a TV coaxial cable circuit. The appeal of a cable modem to a cable TV operator is simple: Put the cable modem on a home cable TV line, provide the subscriber a high-speed circuit to the Internet and the Web, and charge extra for the privilege. The appeal of a cable modem to a user is higher speed. Friends who have such cable modems are in love with them. After using a cable modem to surf the Internet, they all tell me they would never, ever go back to a dial-up connection.
Because the cable modem system effectively turns the cable TV system into a very large LAN, users have to share the available bandwidth with any other active users on the same node, which will result in a reduction in data throughput as the number of users increases. This characteristic is the key difference between cable modem systems and the xDSL solutions which telcos are deploying, where the bandwidth to the user is dedicated. See also 10Base-T, DOCSIS, Modem, NIC and SNMP. www.cable-modems.org.

Cable Modem Termination System CMTS. To deliver data services over a cable network, one six-MHz television channel (in the 50-750 MHz range) is typically allocated for downstream traffic to homes and another channel (in the 5-42 MHz band) is used to carry upstream signals. A headend CMTS communicates through these channels with cable modems located in subscriber homes to create a virtual LAN connection.

Cable Normal Switch A mechanism incorporated into a consumer television receiver which allows the user to select the channel assignment plan. In older receivers, this mechanism is usually a physical switch; in newer receivers, it is usually incorporated as an option in the setup menu. All cable/normal switches allow two choices: "standard" (sometimes called "normal" or "off air") which tunes to the channel assignments used by broadcast stations for over-the-air transmission; and "cable" (sometimes called "CATV" or "STD") which tunes to cable channels. Many receivers also include a third option called HRC or Harmonically-Related Carriers.

Cable Plant A term which refers to the physical connection media (optical fiber, copper wiring, connectors, splicers, etc.) in a local area network. It is a term also used less frequently by the telephone company to mean all its outside cables — those going from the central office to the subscribers' offices.

Cable Programming Service Any tier of cable television programming except: - The basic tier (see Basic Cable Television Service). - Any programming offered on a per-channel or per-program basis.

Cable Protection There are three basic types of protection in addition to standard plastic cladding:
• ElectroMagnetic (EM) Shielding: Prevents passive coupling. EM shielding can be a metallic conduit or metal wrapping-with appropriate grounding-on the wires.
• Penetration-Resistant Conduit: Used to secure the cable from cutting or tapping. Note, however, not all penetration-resistant conduits provide EM shielding.
• Pressurized Conduit: Detects intrusion by monitoring for pressure loss. Fiber optic cable is extremely difficult to tap and if tapped, the intrusion can be detected through signal attenuation. But since fiber optic cable can be cut, penetration-resistant conduit is recommended to protect the cable.

Cable Racking Framework fastened to bays to support cabling between them.

Cable Reregulation Act Of 1992 Cable Reregulation Bill 1515 passed Congress in October 1992, forcing the FCC to reregulate cable television and cable television rates (after the Cable Act of 1984 effectively de-regulated the cable TV industry). After the Act was passed, the FCC forced the industry to reduce its rates by 10% in 1993 and then again by 7% in 1994.

C

Cable Riser Cable running vertically in a multi-story building to serve the upper floors.

Cable Run Conduit used to run cables through a building. Also, path taken by a cable or group of cables.

Cable Scanner A device which tests coaxial, twisted-pair, and fiber-optic cable. It measures the length of a cable segment, tests for opens and shorts, and can report on the distance to the problem so the problem can be found and fixed. Many scanners also indicate if a cable segment has RFI or EMI.

Cable Sheath A covering over the conductor assembly that may include one or more metallic members, strength members, or jackets. See Cable Shield.

Cable Shield A metallic component of the cable sheath which prevents outside electrical interference and drains off current induced by lightning.

Cable Stripper 1. Tool used to strip the jackets off ALPETH and lead-jacketed telephone cable. Cable strippers include cable knives and snips.
2. A professional or amateur stripper who appears on X-rated, or community access channels. Quality varies widely. Pay is often non-existent.

Cable Telephony Cable Telephony is transmitting anything other than TV pictures over a cable TV system. That "anything" might be anything from a data connection to the Internet to simple, standard, analog voice phone calls — local, long distance and international. Typically transmitting anything other than TV over the standard coaxial cable CATV providers install at your house requires a cable modem. See Cable Modem.

Cable Television Relay Station CARS. A fixed or mobile station used for the transmission of television and related audio signals, signals of standard and FM broadcast stations, signals of instructional television fixed stations, and cablecasting from the point of reception to a terminal point from which the signals are distributed to the public.

Cable Type The type of cable used. Also called the media. Examples are coaxial, UTP (Unshielded Twisted Pair), STP (Shielded Twisted Pair) and fiber. Factors including cost, connectivity and bandwidth are important in determining cable type. Choosing cable is getting more and more complex. Our tip: Choose and buy well in advance of when you'll need it. The cable you want will not always be in stock.

Cable Vault Room under the main distribution frame in a central office building. Cables from the subscribers lines come into the building through the cable vault. From here they snake their way up to the main distribution frame. The cable vault looks like a bad B-movie portrayal of Hell, replete with thousands of dangerous black snakes. Cable vaults are prime targets for the spontaneous starting of fires. They should be protected with Halon gas, but usually aren't because some parts of the phone industry think Halon is too expensive.

Cable Weight Expressed in lbs per 1000 (without reel weight included). Affects sag, span and size of the messenger in aerial applications.

Cablecast Cablecasting. Non-broadcast radio or television programming transmitted by a cable television system to its subscribers. Cablecast programming may be originated by the cable operator itself ("origination cablecasting" or "local origination") or by an access organization.

Cablegram Service An MCI definition. An MCI International service which provides cablegram communication to International destinations through the use of a computerized message switching center in New York City.

Cablehead The point where a marine cable connects to terrestrial facilities.

CableLabs Cable Television Laboratories, Inc. A research and development consortium of cable television system operators established in 1988. CableLabs plans and funds research and development projects to help member companies and the cable industry take advantage of opportunities and meet challenges in the telecommunications industry. A

MDMF Multiple Data Message Format. See Caller ID Message Format.

MDN Mobile Dialing Number. The originating telephone number of the cellular caller.

MDPE Medium-Density PolyEthelyne. A type of plastic material used to manufacture jacketing for cable systems.

MDQ Market Driven Quality. An IBM term of the mid-1980s.

MDRAM Multibank Dynamic Random Access Memory. Memory normally used in video boards that boosts extended performance with high bandwidth and short access times. The MDRAM chip can access several memory banks at a time.

MDS 1. An FCC term for a fixed station operating between 2.15 and 2.162 GHz.
2. Multi-Point Distribution Service.

MDSI Message Delivery Service Interoffice. Data link using a 9600 baud modem asynchronous 10-bit character transmission. An obsolete term.

MDT Mean Down Time.

MDU 1. Message Display Unit. See Readerboard.
2. Multiple Dwelling Unit. Any housing structure that is broken into more than one living area to accommodate multiple "family" units (apartment buildings, condominiums, duplexes, etc.).

MDUs Multiple Dwelling Units. A telephony jargon word for high-rise apartment buildings.

MDVC Mobile Digital Voice Channel. The channel between a mobile phone and a cell site antenna in a digital cellular or PCS environment. The MDVC supports both voice and data transmission, although the allocated bandwidth is designed primarily to support voice. Signaling and control functions take place over separate channels set aside specifically for that purpose.

MDWDM Metropolitan dense wave division multiplexing. It is DWDM technology which boosts the carrying capacity of fiber optic telecommunication networks. See DWDM.

ME Mechanical Engineer.

MEA Metropolitan Economic Area. See Metropolitan Statistical Area and MSA.

Meaconing A system for receiving radio beacon signals and retransmitting them on the same frequency to confuse navigation and cause inaccurate bearings to be obtained by aircraft or ground stations.

Mean The sum of all items divided by the number of items, e.g., for the five numbers 7, 7, 8, 10, and 11, the mean is (7 + 7 + 8 + 10 + 11)/5 = 43/5 = 8.6. The average (also the arithmetic average) and the mean are the same. What's different is the median. The median of a set is the number that divides the set in half, so that as many numbers are larger than the median as are smaller. The median of 7, 7, 8, 10, and 11 is 8. If the set has an even number of elements, the median is the number halfway between the middle pair. the median is widely used as a measure of central tendency. See several Mean definitions below.

Mean Busy Hour For a telephone line or group of lines or a switch the Mean Busy Hour is the 60 minute period where traffic is the greatest.

Mean Deviation An average of all deviations, plus or minus from the mean. It is occasionally used as a measure of dispersion.

Mean Opinion Score See MOS.

Mean Power Of A Radio Transmitter The average power supplied to the antenna transmission line by a transmitter during an interval of time sufficiently long compared with the lowest frequency encountered in the modulation taken under normal operating conditions. Normally, a time of 0.1 second, during which the mean power is greatest, will be selected.

Mean Time Between Failure MTBF. The average time a manufacturer estimates before a failure occurs in a component, a printed circuit board or a complete telephone system. One must check, since MTBFs are cumulative. MTBF was developed and administered by the U.S. military for purposes of estimating maintenance levels required by various devices and systems. Since accurate statistics require a basis of "failures per million hours of operation," an MTBF estimate on a single device is not very accurate; it would take 114 years to see if the device really had that many failures! Similarly, since the MTBF is an estimate of averages, half of the devices can be expected to fail before then, and half after. MTBF cannot be used as a guarantee. Telecommunications systems operate on the principle of "Availability," for which there is a body of CCITT Recommendations.

Mean Time Between Outages MTBO. The mean time between equipment failures or significant outages which essentially render transmission useless. See Mean Time Between Failure.

Mean Time To Repair MTTR. The vendor's estimated average time required to do repairs on equipment.

Mean Time To Service Restoral MTSR. The mean time to restore service following system failures that result in a service outage. The time to restore includes all time from the occurrence of the failure until the restoral of service.

Measured Load The load that is indicated by the average number of busy servers in a group over a given time interval, usually determined with a scanning device.

Measured Rate A message rate structure in which the monthly phone line rental includes a specified number of calls within a defined area, plus a charge for additional calls. See Local Measured Service.

Measured Service Also known as USAGE SENSITIVE PRICING (USP). A local phone company method of pricing used to bill local phone calls. Measured service is often charged on the number of calls, the time of day, the distance traveled and the length of the call. See Local Measured Service.

Measurement Interval A Frame Relay term defining the interval of time which the carrier uses to measure burst rates which exceed the CIR, as well as the length of the bursts.

Meatware People. See also Vaporware.

MECAB Multiple Exchange Carrier Access Billing.

MECAL Master Event Calendar.

MECCA Multiplex Engineering Control Center Activity.

Mechanic A programmer.

Mechanical Equipment Room A room serving the space needs for HVAC and other building systems other than telecommunications equipment. These are often special-purpose rooms.

Mechanical Hold A very basic line-holding mechanism used on simple two- and three-line phones that operated by placing a short circuit or a resistor across one phone line while talking on another. Chief disadvantage was that a call put on hold at one phone could not be taken off hold at another phone. Inexpensive multi-line phones with electronic holds largely replaced mechanical holds in the 1980s.

Mechanical Loop Test MLT. Also called Direct-Access Test Unit (DATU) added or built into a central office switch. With MLT a technician can execute tests for shorts, opens and grounds remotely. The technician gets a digital voice, enters a password and is given a series of options. The technician can get results as a digital recording or through an alphanumeric pager. MLT units can send a locating tone as TIP, RING or a combination of both. The unit can short lines and remove battery voltage for testing.

Mechanical Splice A splice in which optical glass fibers are joined mechanically (e.g., glued or crimped in place) but not fused (i.e. melted) together.

Mechanical Stripping Removing the coating from a fiber using a tool similar to those used for removing insulation from wires.

Mechanized Calling Card Service MCCS was formerly known as ABC Service. MCCS is a central office switch feature that automatically bills credit card calls made on DDD (direct distance dial) rates without the involvement of an operator.

Mechanized Line Testing MLT. The system provides computer control of accurate and extensive loop testing functions in the customer contact, screening, testing, dispatch and closeout phases of trouble report handling. It also provides full diagnostic outputs instead of just pass/fail indications.

MECOD Multiple Exchange Carriers Ordering and Design.

Media In the context of telecommunications, media is most often the conduit or link that carries transmissions. Transport media include coaxial cable, copper wire, radio waves, waveguide and fiber.

Media Access Control MAC. The real term is Medium Access Control. But some naughty people call it, incorrectly, Media Access Control. See Medium Access Control for a full explanation.

Media Access Control Convergence Functions MCF. Media Access Control Convergence performs functions or processes which map information received from IEEE 802.2 Layer 2 LLC into a format acceptable to the lower layer medium.

Media Compatible Usually used to refer to floppy disk media. Even though two different computers (e.g. an AT&T PC 6300 and an Apple IIe) both use 5 1/4 inch floppy disks, the information recorded on them is recorded in a different format and thus, they are not media compatible. You can put one disk in another's machine. But it won't work. You'll get a dumb error message.

Media Filter A device used to convert the output signal from a token-ring adapter board to work with a specific type of wiring. For example, a media filter can link 16Mbps token-ring network interface cards with unshielded twisted-pair (UTP) wiring, thus saving

M

the expense of additional cable runs.

Media Gateway Controller See MGCP.

Media Gateway See MGCP.

Media Gateway Control Protocol See MGCP.

Media Independent Interface MII. A part of the Fast Ethernet specification. The MII replaces 10Base-T Ethernet's Attachment Unit Interface (AUI), and is used to connect the MAC layer to the physical layer. The MII establishes a single interface for the three 100Base-T media specifications (100Base-TX, 100Base-T4, and 100Base-FX).

Media Interface Connector An optical fiber connector which links the fiber media to the FDDI node or another cable.

Media Path Same as wire run. The means by which telephone signals are conveyed from the Network Interface Jack to the Communications Outlet.

Media Processor A special microprocessor whose job is to perform processing for multimedia devices, e.g. videophones, audio, computer telephony devices, voice recognition and 3-D, while the computer's main microprocessor (e.g. a Pentium) handled the basic processing and input/output (I/O) processing. Such media processors might have all the characteristics of digital signal processors and then some. See also MMX.

Media Processing The processing of transactions during a telephone call; these transaction may include fax operations, speech recognition and synthesis, Touch Tone recognition, voice and fax store-and-forward messaging, and the conversion of messages from one format to another (such as from text to voice, or fax to text).

Media Server A new term for a file server on a local area network which contains files containing voice, images, pictures, video, etc. In short, a media server is a repository for media of all types. Media servers are also called file servers. Here's a definition of Media Server, courtesy of Oracle Corporation, writing in early 1994: "The media server harnesses the power of the fastest computers ever built — massively parallel computers. Media servers support diverse clients so that users don't have to discard existing systems. They provide storage, network interfaces and memory — plus support for all forms of multimedia information. Because they use thousands of low-cost microprocessors, media servers offer astonishing performance at low cost."

Media Service Instance A logical server providing access to media services (e.g., Accessing a DataStream, Sending & Receiving Faxes, Playing & Recording Sounds, Engaging other VRU services) that can be associated with a call through a Media Access Device. See MediaStreamID.

Media Stream The information content carried on a call-that is, what actually is transmitted and received over the line, and can, with the necessary hardware, be read and written by a media stream API.

Media StreamID Allows an association to be established between a given call and Media Services available on a Media Service Instance that can be associated with the call through a Media Access Device. See Media Service Instance.

Media Type A call's media type describes what type of information the call is carrying, such as data or voice. A computing domain can use this information, for example, to route the call to a more appropriate computing domain, such as a data computing domain for an incoming data call.

Median The average and the mean are the same. What's different is the median. See Mean for a full explanation.

Mediation System A wireless telecommunications term. A mediation system provides for three functions for transporting data from one device to another. These include protocol conversion, message routing, and store-and-forward processing.

Medium 1. The material on which data is recorded; for example, magnetic type, diskette.
2. Any material substance that is, or can be, used for the propagation of signals, usually in the form of modulated radio, light, or acoustic waves, from one point to another, such as optical fiber, cable, wire, dielectric slab, water, air, or free space.

Medium Access Control MAC. The IEEE sublayer in a LAN (Local Area Network) which controls access to the shared medium by LAN-attached devices. In the context of the OSI Reference Model, the MAC layer extends above to the Data Link Layer (Layer 2), and below to the Physical Layer (Layer 1). Within the MAC sublayer are defined Data Link Layer options which specify the basis on which devices access the shared medium, and the basis on which congestion control is exercised. Defined at the Physical Layer are media options such as UTP (Unshielded Twisted Pair) CAT 3, 4, and 5 (Categories of wire); STP (Shielded Twisted Pair); fiber optic cable; and wireless radio and infrared. Specific IEEE MAC standards are defined for LANs such as CSMA/CD (802.3), Token Passing Bus (802.4), Token Passing Ring (802.5), Metropolitan Area Networks (802.6), and Wireless LANs (802.11). The MAC sublayer works in conjunction with the Logical Link Control Layer of the IEEE model; at this higher level are defined specific LLC conventions such as frame format and addressing.

Medium Attachment Unit A device used in a data station to couple the data terminal equipment (DTE) to the transmission medium.

Medium Dependent Interface MDI-X. The physical components of a network interface which handle the electrical or optical connection to a cable. This includes the connector, transceivers, and other physical layer components. MDI-X refers to a physical connection which includes an internal crossover of the transmit and receive signals. All standard repeater ports are MDI-X and are often marked with just an X by the port. Some repeater ports are changeable to a DTE port. In this case, the port is changed to a MDI port for connection to a MDI-X port on another repeater. An example of a DTE port is the connection on a NIC.

Medium Earth Orbit MEO. Medium (or Middle) Earth Orbit satellites orbit the earth at distances between LEOs and GEOs (Low Earth Orbit satellites and Geosynchronous Earth Orbit satellites). Because MEOs operate at heights greater than LEOs, they have larger footprints, or areas of coverage, so that fewer satellites are needed to provide complete coverage over the earth. The planned Odyssey system, which will have 12 satellites, is one MEO with complete world coverage. See also LEO, MEO, GEO and Geosynchronous.

Medium Frequency MF. Radio frequencies from 300 KHz to 3000 KHz.

Medium Interface Connector MIC. In LAN/MAN systems, the connector at the interface point between the bus interface unit and the terminal, termed the medium interface point.

MEE Multiplex Equipment Engineering.

Meet-Me Conference A teleconferencing term. Meet-Me Conferencing is an arrangement by which you can dial a specific, pre-determined telephone number and security access code to join a conference with other participants. You are automatically connected to the conference through a conference bridge. Conference participants may call in at a preset time or may be directed to do so by a conference coordinator. Meet-Me Conferences may be set up through a teleconferencing service provider, generally with the capability to conference thousands of participants. It also can be provided through a phone system, such as a PBX, key system or hybrid. Some phone systems restrict this to intercom circuits only. In almost all phone systems there is a maximum number of parties that can be connected in such conference at one time.

Meet-Me Intercom Conference Dial a special number ("access code") and any telephone can join an intercom conference call.

Meet-Me Page A feature which allows a person to answer an intercom page from any phone in the system.

Meet Point A location at which the facilities of two carriers connect.

Meet-Point Billing This is a billing arrangement that applies when two Local Exchange Carriers in the same LATA are used to complete a private line circuit.

Mega A prefix meaning one million, also represented as an M. MEGABIT = one million bits. MEGABYTE = one million bytes. MEGAHERTZ = one million cycles per second. See also Megabyte.

Megabits per Second A measurement of speed indicating that one million bits of information travel a certain distance in one second.

Megabyte MB. A combination of the Greek "mega," meaning "large," and the English "bite," meaning "a small amount of food." A unit of measurement for physical data storage on some form of storage device-hard disk, optical disk, RAM memory, etc. The actual definition can be confusing, since there are two measurements. In the metric system, a megabyte is 1,000,000 bytes. In the computer world, things tend to be measured in binary terms — 1s and 0s. In binary terms, a megabyte is 2 to the 20th power, i.e., 1,048,576 bytes, which is the closest power of two to one million.i.e. 1024 x 1024. A megabyte can be either a decimal (metric) megabyte or a binary megabyte, depending on the context. A decimal megabyte also is called a "millionsbyte" or a "miobyte," and is used to describe capacity in newer ROM BIOS drives. Binary megabytes are used to describe capacity in DOS FSISK, Windows 3.x File Manager, and CMOS setup in older ROM BIOS drives. Here is a summary of sizes:
MB = Megabyte (2 to the 20th power)
GB = Gigabyte (2 to the 30th power)
TB = Terabyte (2 to the 40th power)

that receives the data from a PAD Packet Assembly Disassembler) through a modem. The PSE makes and holds copies of each packet before sending them to the PSE they're addressed to. After the far-end PSE acknowledges receipt of the original, the copies are discarded.

Packet Switching Network A network designed to carry data in the form of packets. See Packet Switching.

Packet Telephony Another name for Internet Telephony. Also called Voice Over the Internet. See VoIP.

Packet Tracing The monitoring and reporting a particular packet addresses or types for diagnostic purposes.

Packet Type Identifier In packet data networking technology, the third octet in the packet header that identifies the packet's function and, if applicable, its sequence number.

Packet-centric A growing focus in the telecom industry away from voice-dominant (circuit-centric) networks and toward IP packet networks as the future delivery system for combined data and telephony. Definition courtesy Wireless Magazine.

PacketCable PacketCable is a project conducted by CableLabs and its member companies aimed at identifying, qualifying and supporting Internet-based voice and video products and cable systems.

Packetized Video First, read the definition of "Packet Switching." Then read the definition of "Packetized Voice" just below. The concept of packetized video is basically the same as that of packetized voice. A video camera feeds the signal into a codec, which converts the native analog signal into a digital format, and segments the data into data packets. The packets are sent across a packet network as a packet stream for reassembly by a codec on the receiving end of the transmission before presentation on a monitor. While packetized video performance is improving in quality through the application of increasingly sophisticated video compression techniques, it suffers from the same intrinsic packet-switching characteristics as does packetized voice. Namely, packet latency and loss. The result often is a video image which is less than pleasing. Note that voice and video are isochronous data, meaning that they are stream-oriented. In other words, the transmitting device must have regular and reliable access to the network. Further, the network must transport and deliver the data on a regular and reliable basis in order that a stream of information reach the presentation device. Such regular and reliable ingress, transport and egress of data results in a image of consistent quality. As packet-switched networks are not designed to support isochronous data communications, they generally are considered unsuitable for voice and video communications. Additionally, video is very bandwidth-intensive, thereby placing additional stress on packet-switched networks such as the Internet, which already is overloaded.

An example might help. Let's say that you are using an inexpensive ($200 or so) videoconferencing package consisting of a camera and software. Your friend has the same package. At a pre-arranged time, you place a call over the Internet to establish a videoconference. At two fps (frames per second) the videoconference goes along pretty smoothly, although both the video and voice quality are a bit rough. At some point, your friend turns his head quickly; at the same time, the Internet bogs down. The packet which contains the image of your friend's nose gets delayed or lost in the network. The video image of your friend now is missing a nose. Funny the first time, aggravating the second, maddening thereafter. The upside is that the videoconference is cheap, if not free, depending on your cost of Internet access. See also Packet Switching, Videoconferencing Internet and Isochronous.

Packetized Voice First read the definition of "Packet Switching" just above. The idea is to digitize voice and, compress it, and then slice it up into packets and send those packets from the sender by various routes and assemble them as they get to the receiver. Packet switching for data makes sense. Packet switching for voice has not made sense because the voice is too sensitive to latency, or delay, especially the variable delay which is part and parcel of packet-switched networking. Recently developed software and DSP hardware, which employs sophisticated compression techniques has improved the ability to conduct "reasonable" quality packet voice conversations over the Internet. See Packet Switching, IP Telephony, TAPI 3.0.

PacketNet Sprint's internal X.25 Packet Network.

PACS Personal Communications Access System. PACS is a cellular system providing limited, regional mobility in a given area. It provides mobility between that of a cordless phone and a full-fledged cellular system. Originally developed by Bell Labs in the early 1980s, PACS is a comprehensive framework for the deployment of PCS and applies to both licensed and unlicensed applications. Now it is approved by the TIA and Exchange Carriers Standards Associations. Today's currently implemented versions of PCS are "up-banded" versions of the 900 MHz AMPS and GSM cellular standards.

PACT Siemens' PBX And Computer Teaming. It defines protocols between Siemens PBXs and external computers.

Pad 1. A device inserted into a circuit to introduce loss, i.e., to reduce the level of a signal. "Level" is a measurement of amplitude (signal power) at a specified point in a circuit known as a Transmission Level Point (TLP). "Loss" is the measurement of the decrease in amplitude between two TLPs, and is measured in decibels (dB). A pad may consist of any combination of inductors, resistors and capacitors.
2. Packet Assembler/Disassembler. A device that accepts characters from a terminal or host computer and puts the characters into packets that can be handled by a packet switching network. It also accepts packets from the network, and disassembles them into character streams that can be handled by the terminal or host. PADs generally are associated with X.25, an ITU-T Standards Recommendation for an access protocol used in older packet-switched networks. See also X.25.
3. A concrete slab used as the foundation for a microwave radio tower or satellite dish.

Pad Characters In (primarily) synchronous transmission, characters that are inserted to ensure that the first and last characters of a packet or block are received correctly. Inserted characters that aid in clock synchronization at the receiving end of a synchronous transmission link. Also called Fill Characters.

Pad Switching A technique of automatically cutting a transmission loss pad into and out of a transmission circuit for different operating conditions.

PAF File A British term. Post Office Address file, a publicly available data file that, when integrated with an application, links postcodes to full addresses. When using a PAF file, an agent can save time by entering only the postcode. The PAF file automatically inserts post town, street and country.

Page A chunk of information, like a document or file, on the Web. A hypermedia document as viewed through a World Wide Web browser. Pages are the way you make information available on the Web. They can contain text, black and white and color photographs, audio and video.

Page hits A measure of the number of Web pages accessed at a particular site, or of the number of times a single page is accessed.

Page Mirroring You're surfing the Internet. You come upon an Web site and find something you want to buy. It has a button that says, "To speak to an Agent, push here." You do. An agent in a distant office calls you on another phone line. You're now both speaking to each other and your agent is also seeing the screen you're seeing. As you move to different screens (to different pages), the agent sees the same screens you are looking at. This is called page mirroring. At present, the technology won't allow the agent to move the pages which you see. Only you can move the screens.

Page Recall A feature which allows subscribers to telephone a toll-free number to check messages at any time. Messages are stored in the IVR (Interactive Voice Response) device for a period of 99 hours.

Page Scan State A Bluetooth term. A mode where a device listens for page strains containing its own device access code (DAC). A mode that a RemDev enters when advertising that a service is available.

Page State A Bluetooth term. A mode that a LocDev enters when searching for services. The LocDev sends out a page to notify other devices that it wants to know about the other devices and/or their services.

Page train A Bluetooth term. A series of paging messages sent over the baseband.

Page Zone A local area in the office that can receive directed Page announcements independently of the remainder of the office.

Pager A small one-way (typically) wireless receiver you carry with you. When someone wants you, they make your pager receiver alert you via a tone or a vibrator. They can activate your pager in a number of ways, including dialing your pager digits directly into a computer; calling your pager from a telephone; or the old, low-tech approach of giving your name and pager number to an operator who then punches out your numbers. Pagers have become small, cheap and very reliable. Monthly service costs have dropped and the area which you can be paged in most areas has widened dramatically. With most pagers you can be reached in most major metropolitan areas of the US. This minor miracle is accomplished through a combination of satellite and terrestrial radio networks; if the network can't reach you to deliver the page, it will store the message until you can be reached. Some pagers also display small alphanumeric messages-like phone numbers to call and

P

don't have to return. It closes deals that can't wait. And it gives customers immediate answers. In short, it improves corporate efficiency and customer satisfaction.

Voice over IP VoIP. The technology used to transmit voice conversations over a data network using the Internet Protocol. Such data network may be the Internet or a corporate Intranet, or managed networks typically used by long and local service traditional providers and ISPs that use VoIP. There are several potential benefits to moving voice over a data network using Internet Protocol: First, You may save some money. Second, you may achieve benefits of managing a voice and data network as one network. Third, if you have IP phones, moves, adds and changes will be easier and cheaper. (IP phones have individual numbers, with memories, user profiles and software upgrades are typically centrally managed using standard computing systems. So they're more "user friendly.") And fourth — the key attraction of IP telephony — is added (and integrated) new services, including integrated messaging, bandwidth on demand, voice emails, the development of "voice portals" on the Web and the much simplified setting up, tearing down and transferring of phone calls. See Internet Protocol.

Voice Paging Access Gives attendants and phone users the ability to dial loudspeaker paging equipment throughout the building. An unbelievably useful feature, if your people are prone to wander.

Voice Portal Call a phone number, have an interactive voice response system answer you, respond to your words with speech recognition, read your emails with text-to-speech skills, perhaps even allowing you to "surf" the Web. The classic definition of a portal is a door, gate, or entrance, especially one of imposing appearance, as to a palace. In the Internet / World Wide Web business, a portal is a site, which the owner positions (through marketing) as an entrance to other sites on the Internet. There are two types of portals — the conventional PC-based, browser based — and the newer one using the telephone. For a bigger explanation of a portal, see Portal.

Voice Print See Voiceprint.

Voice Processing Think of voice processing as a voice computer. Where a computer has a keyboard for entering information, a voice processing system recognizes touch-tones from remote telephones. It may also recognize spoken words. Where a computer has a screen for showing results, a voice processing system uses a digitized synthesized voice to "read" the screen to the distant caller.

Whatever a computer can do, a voice processing system can too, from looking up train timetables to moving calls around a business (auto attendant) to taking messages (voice mail). The only limitation on a voice processing system is that you can't present as many alternatives on a phone as you can on a screen. The caller's brain simply can't remember more than a few. With voice processing, you have to present the menus in smaller chunks.

Voice processing is the broad term made up of two narrower terms — call processing and content processing. Call processing consists of physically moving the call around. Think of call processing as switching. Content consists of actually doing something to the call's content, like digitizing it and storing it on a hard disk, or editing it, or recognizing it (voice recognition) or some purpose (e.g. using it as input into a computer program.) See Voice Board, Voice Response Unit and Voice Server.

Voice Profile for Internet Messaging See VPIM.

Voice Recognition The ability of a machine to recognize your particular voice. This contrasts with speech recognition, which is different. Speech recognition is the ability of a machine to understand human speech — yours and most everyone else's. Voice recognition needs training. Speech recognition doesn't. See Speaker Dependent and Speaker Independent Voice Recognition.

Voice Response Unit VRU. Think of a Voice Response Unit (also called Interactive Voice Response Unit) as a voice computer. Where a computer has a keyboard for entering information, an IVR uses remote touchtone telephones. Where a computer has a screen for showing the results, an IVR uses a digitized synthesized voice to "read" the screen to the distant caller. An IVR can do whatever a computer can, from looking up train timetables to moving calls around an automatic call distributor (ACD). The only limitation on an IVR is that you can't present as many alternatives on a phone as you can on a screen. The caller's brain simply won't remember more than a few. With IVR, you have to present the menus in smaller chunks. See IVR and Voice Board.

Voice Retrieval Message system that stores verbal messages (from callers or operator) for automatic retrieval at the customer's convenience.

Voice Ring Multiple Digital Intertie Buses connected in series to all nodes. Provides extra channels for voice data transmission when direct link (DI) channels are busy.

Voice Server A PC sitting on a LAN (Local Area Network) and containing voice files which are accessible by the PCs on the LAN. Such voice files may be transmitted on the LAN or over phone lines under the control of the PCs on the LAN. A voice server might contain voice mail. It might contain voice annotated electronic mail. Its primary function is to store voice in such a way that it's accessible easily. Voice servers are typically faster, have more disk capacity and more backup provisions than normal PCs. According to a letter I received in early May, 1993 from the lawyers for a company called Digital Sound Corporation, that company owns federal trademark registration number 1,324,258 for the mark Voiceserver, spelled as one word, not two.

Voice Service Personality A new name for dial tone.

Voice Store And Forward Voice mail. A PBX service that allows voice messages to be stored digitally in secondary storage and retrieved remotely by dialing access and identification codes. See Voice Mail System.

Voice Switched A device which responds to voice. When the device hears a voice, it turns on and transmits it, muting the receive side. The most common voice-switched device is the desk speakerphone. With voice switching, it's easy to hog a circuit. Just keep making a noise. Watch out for voice hogging. If you're calling someone and waiting for them by listening in on your speakerphone, mute your speakerphone. This way you'll hear them when they answer.

Voice Switching Equipment used in voice and video conferences. The equipment is activated by sounds of sufficient amplitude; hopefully speech, but also loud noises. Fast switching activates microphones so that only one conference participant can speak at a time. See also Voice Activated Video.

Voice Terminal A pretentious AT&T term for a Telephone.

Voice Verification The process of verifying one's claimed identity through analyzing voice patterns.

Voiceband A transmission service with a bandwidth considered suitable for transmission of audio signals. The frequency range generally is 300 or 500 hertz to 3,000 or 3,400 hertz — the frequency range the common analog home phone service is made at.

VoFR Voice over Frame Relay.

Voiceprint A voice recognition term. A voiceprint is a speech template used to recognize and verify callers. For example, Home shopping Network,
voice systems
When a system is operating,
the user's speech is compared to the stored voice prints. If they match, the system recognizes the word and executes the command.

VoIP Voice over Internet Protocol. The technology used to transmit voice conversations over a data network using the Internet Protocol. Such data network may be the Internet or a corporate Intranet. For a much longer explanation, see Voice over IP and VoIP Forum.

VoIP Forum Voice over Internet Protocol. The Voice over IP Forum was formed in 1996 by Cisco Systems, VocalTec, Dialogic, 3Com, Netspeak and others as a working group of the International Multimedia Teleconferencing Consortium (IMTC), which promotes the implementation of the ITU-T H.323 standard. The VoIP Forum is focused on extending the ITU-T standards to provide implementation recommendations as a means of supporting Voice over IP in order that devices of disparate manufacture can support voice communications over packet networks such as the Internet. By way of example, the VoIP Forum intends to establish directory services standards in order that Internet voice users can find each other. They also plan to port touch-tone signals to the Internet to allow the use of ACDs and voice mail systems. See also VON Coalition.

VolanoMark VolanoMark is a popular Java benchmark for measuring server throughput... it measures messages per second.

Volatile Storage Computer storage that is erased when power is turned off. RAM is volatile storage.

Volser An MCI term used to denote a volume of calls. Based on the words "Volume Serial." The term "Volser" can be applied to the manual collection of calls from a switch on a switch tape or through call data transmitted via NEMAS.

Volt The unit of measurement of electromotive force. Voltage is always expressed as the potential difference in available energy between two points. One volt is the force required to produce a current of one ampere through a resistance or impedance of one ohm.

Volt Meter An instrument for measuring voltages, resistance and current.

Voltage Electricity is a essentially a flow of electrons. They're pushed into a gadget — toaster, computer, phone — on one wire and they sucked out on the other wire. For this movement of electrons to occur there must be "pressure," just as there must be pressure in

Appendix C

Microsoft

Microsoft

Computer Dictionary

Fifth Edition

PUBLISHED BY
Microsoft Press
A Division of Microsoft Corporation
One Microsoft Way
Redmond, Washington 98052-6399

Library of Congress Cataloging-in-Publication Data
Microsoft Computer Dictionary.--5th ed.
p. ; cm.
ISBN 0-7356-1495-4
1. Computers--Dictionaries. 2. Microcomputers--Dictionaries.

AQ76.5. M52267 2002
004'.03--dc21 200219714

Printed and bound in the United States of America.

1 2 3 4 5 6 7 8 9 QWT 7 6 5 4 3 2

Distributed in Canada by Penguin Books Canada Limited.

A CIP catalogue record for this book is available from the British Library.

Microsoft Press books are available through booksellers and distributors worldwide. For further information about international editions, contact your local Microsoft Corporation office or contact Microsoft Press International directly at fax (425) 936-7329. Visit our Web site at www.microsoft.com/mspress. Send comments to *mspinput@microsoft.com*.

Acquisitions Editor: Alex Blanton
Project Editor: Sandra Haynes

Body Part No. X08-41929

Advanced Encryption Standard *n. See* AES.

Advanced Interactive Executive *n. See* AIX.

Advanced Mobile Phone Service *n. See* AMPS.

Advanced Power Management *n.* An older power management technology used in mobile PCs before the implementation of Advanced Configuration and Power Interface (ACPI). Advanced Power Management is a software interface that functions between the BIOS power-management software that is specific to the hardware and a power-management policy driver that is run by the operating system. *Acronym:* APM.

Advanced Program-to-Program Communication *n. See* APPC.

Advanced Research Projects Agency Network *n. See* ARPANET.

Advanced RISC *n.* Short for **Advanced** reduced instruction set computing. A specification for a RISC microchip architecture and system environment designed by MIPS Computer Systems to provide binary compatibility among software applications. *See also* RISC.

Advanced RISC Computing Specification *n.* The minimum hardware requirements enabling a RISC-based system to comply with the Advanced Computing Environment standard. *See also* Advanced RISC.

Advanced RISC Machines *n. See* ARM.

Advanced SCSI Programming Interface *n.* An interface specification developed by Adaptec, Inc., for sending commands to SCSI host adapters. The interface provides an abstraction layer that insulates the programmer from considerations of the particular host adapter used. *Acronym:* ASPI.*See also* adapter, SCSI.

Advanced Streaming Format *n.* An open file format specification for streaming multimedia files containing text, graphics, sound, video, and animation. Advanced Streaming Format (ASF) does not define the format for any media streams within the file. Rather, it defines a standardized, extensible file "container" that is not dependent on a particular operating system or communication protocol, or on a particular method (such as HTML or MPEG-4) used to compose the data stream in the file. An ASF file consists of three objects: a Header object containing information about the file itself, a Data object containing the media streams, and an optional Index object that can help support random access to data within the file. The ASF specification has been submitted to the ISO (International Organization for Standardization) for consideration. *Acronym:* ASF.*See also* streaming.

adventure game *n.* A role-playing computer game in which the player becomes a character in a narrative. In order to complete the game, the player must solve problems and avoid or overcome attacks and other forms of interference from the game's environment and other characters. The first adventure game was called "Adventure." It was developed in 1976 by Will Crowther of Bolt, Baranek & Newman. *See also* arcade game, computer game, role-playing game.

AE *n.* Acronym for application entity. In the ISO/OSI reference model, one of the two software parties involved in a communications session. *See also* ISO/OSI reference model.

A/E/C SYSTEMS conference *n.* Annual conference of the architecture, engineering, and construction industry. The conference promotes the exchange of information on new techniques and technologies used by these industries.

.aero *n.* One of seven new top-level domain names approved in 2000 by the Internet Corporation for Assigned Names and Numbers (ICANN). .aero is meant for use with air-transport industry-related Web sites. The seven new domain names became available for use in the spring of 2001.

AES *n.* Acronym for Advanced Encryption Standard. A cryptographic algorithm specified by the National Institute of Standards and Technology (NIST) to protect sensitive information. AES is specified in three key sizes: 128, 192, and 256 bits. AES replaces the 56-bit key Data Encryption Standard (DES), which was adopted in 1976. *See also* DES.

AFC *n. See* Application Foundation Classes.

AFDW *n. See* Active Framework for Data Warehousing.

affinity *n.* For Network Load Balancing, the method used to associate client requests to cluster hosts. When no affinity is specified, all network requests are load balanced across the cluster without respect to their source. Affinity is implemented by directing all client requests from the same IP address to the same cluster host. *See also* client request, IP address.

AFIPS *n.* Acronym for American Federation of Information Processing Societies. An organization formed in 1961 for the advancement of computing and information-related

ARM *n.* Short for Advanced RISC Machines. A name for any of a group of small, high-performance 32-bit RISC-based microprocessors licensed to various semiconductor manufacturers by designer ARM Limited. ARM chips are notable for their low cost and efficient use of power. They are used in a wide variety of products, including mobile phones, handheld computers, automotive and embedded solutions, and consumer electronics, including digital cameras and game systems. *See also* StrongARM.

ARP *n.* Acronym for Address Resolution Protocol. A TCP/IP protocol for determining the hardware address (or physical address) of a node on a local area network connected to the Internet, when only the IP address (or logical address) is known. An ARP request is sent to the network, and the node that has the IP address responds with its hardware address. Although ARP technically refers only to finding the hardware address, and RARP (for Reverse ARP) refers to the reverse procedure, ARP is commonly used for both senses. *See also* IP address, TCP/IP.

ARPANET *n.* A large wide area network created in the 1960s by the U.S. Department of Defense Advanced Research Projects Agency (ARPA, renamed DARPA in the 1970s) for the free exchange of information between universities and research organizations, although the military also used this network for communications. In the 1980s MILNET, a separate network, was spun off from ARPANET for use by the military. ARPANET was the network from which the Internet evolved. *See also* ALOHAnet, Internet, MILNET.

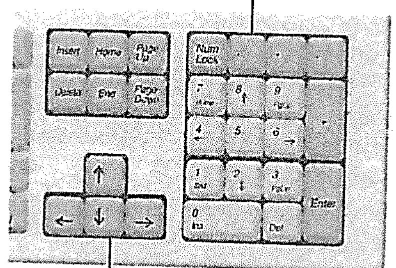
ARP request *n.* Short for Address Resolution Protocol request. An ARP packet containing the Internet address of a host computer. The receiving computer responds with or passes along the corresponding Ethernet address. *See also* ARP, Ethernet, IP address, packet.

array *n.* In programming, a list of data values, all of the same type, any element of which can be referenced by an expression consisting of the array name followed by an indexing expression. Arrays are part of the fundamentals of data structures, which, in turn, are a major fundamental of computer programming. *See also* array element, index[1], record[1], vector.

array element *n.* A data value in an array.

array processor *n.* A group of interconnected, identical processors operating synchronously, often under the control of a central processor.

arrow key *n.* Any of four keys labeled with arrows pointing up, down, left, and right, used to move the cursor vertically or horizontally on the display screen or, in some programs, to extend the highlight. See the illustration.



Arrow key. *When Num Lock is off, the arrow keys on the number keypad can be used.*

ART *n.* Acronym for Adaptive Resonance Theory. First introduced as a theory of human information processing by Stephen Grossberg, ART has evolved into several classes of self-organizing neural networks that use two layers of ideal cases to predict outcome. It is a form of cluster analysis where data is classified or matched to the previously stored pattern it most closely resembles. This data is said to *resonate* with the ideal case layer, which is then updated to reflect the new information. The constant recategorization of input results in a powerful autonomous neural network. *See also* artificial intelligence, cluster analysis, neural network.

article *n.* A message that appears in an Internet newsgroup. *Also called:* post. *See also* newsgroup.

articulation *n.* A series of adjustments applied by a synthesizer to the pitch, volume, and other parameters of an instrument sound to make it more realistic.

artifact *n.* A visible imperfection or distortion in a digital image. Artifacts may be caused by hardware/software limitations or may be a byproduct of compression.

artificial intelligence *n.* The branch of computer science concerned with enabling computers to simulate such aspects of human intelligence as speech recognition, deduction, inference, creative response, the ability to learn

systems integrate computer-aided design and engineering (CAD/CAE), material requirements planning (MRP), and robotic assembly control to provide "paperless" management of the entire manufacturing process. **3.** Acronym for **c**omputer-**i**nput **m**icrofilm. A process in which information stored on microfilm is scanned and the data (both text and graphics) converted into codes that can be used and manipulated by a computer. Computer-input microfilm is similar to processes such as optical character recognition, in which images on paper are scanned and converted to text or graphics. *Compare* COM (definition 4).

CIP *n.* **1.** Short for **C**ommerce **I**nterchange **P**ipeline. A Microsoft technology that provides for secure routing of business data between applications over a public network such as the Internet. CIP is independent of data format and supports encryption and digital signatures, as well as various transport protocols including SMTP, HTTP, DCOM, and EDI value-added networks. Typically, data such as invoices and purchase orders travel over a network through a transmit pipeline and are read from the network by a receive pipeline that decodes and prepares the data for the receiving application. **2.** Short for **C**ommon **I**ndexing **P**rotocol. A protocol defined by the Internet Engineering Task Force (IETF) for enabling servers to share indexing information. CIP was developed to provide servers with a standard means of sharing information about the contents of their databases. With such sharing, a server unable to resolve a particular query would be able to route the query to other servers that might contain the desired information—for example, to find the e-mail address of a particular user on the Web.

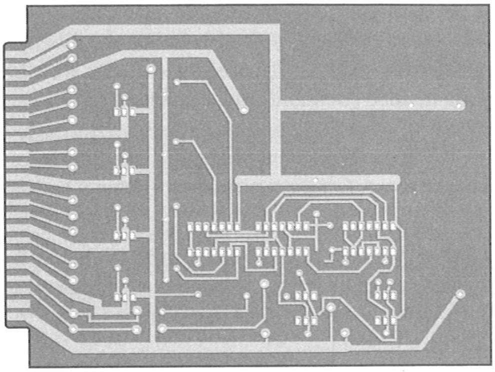
cipher *n.* **1.** A code. **2.** An encoded character. **3.** A zero.

ciphertext *n.* The scrambled or otherwise encoded text of an encrypted message. *See also* encryption.

circuit *n.* **1.** Any path that can carry electrical current. **2.** A combination of electrical components interconnected to perform a particular task. At one level, a computer consists of a single circuit; at another, it consists of hundreds of interconnected circuits.

circuit analyzer *n.* Any device for measuring one or more characteristics of an electrical circuit. Voltage, current, and resistance are the characteristics most commonly measured. Oscilloscopes are circuit analyzers.

circuit board *n.* A flat piece of insulating material, such as epoxy or phenolic resin, on which electrical components are mounted and interconnected to form a circuit. Most modern circuit boards use patterns of copper foil to interconnect the components. The foil layers may be on one or both sides of the board and, in more advanced designs, in several layers within the board. A printed circuit board is one in which the pattern of copper foil is laid down by a printing process such as photolithography. See the illustration. *See also* board, printed circuit board.



Circuit board.

circuit breaker *n.* A switch that opens and cuts off the flow of current when the current exceeds a certain level. Circuit breakers are placed at critical points in circuits to protect against damage that could result from excessive current flow, which is typically caused by component failure. Circuit breakers are often used in place of fuses because they need only to be reset rather than replaced. *Compare* surge protector.

circuit card *n. See* circuit board.

Circuit Data Services *n.* A GTE service that uses circuit switching technology to provide fast data transfer using a laptop computer and cellular telephone. *Acronym:* CDS. *See also* circuit switching.

circuit-switched data *n.* An ISDN option that can be specified for B (bearer) channels that enables an ISDN user to transmit digital data over the channel at 64 Kbps along a point-to-point, dedicated connection for the duration of a call. *Acronym:* CSD. *See also* alternate circuit-switched voice/circuit-switched data, B channel, ISDN. *Compare* circuit-switched voice.

circuit-switched voice *n.* An ISDN option that can be specified for B (bearer) channels that uses the channel to set up a point-to-point, dedicated connection for the digital transmission of voice communications for the duration of a call. *Acronym:* CSV. *See also* alternate circuit-switched

the parts of the system work in harmony so that data is stored safely and accurately. Application programs manage data by receiving and processing input according to the user's commands, and sending results to an output device or to disk storage. The user also is responsible for data management by acquiring data, labeling and organizing disks, backing up data, archiving files, and removing unneeded material from the hard disk.

data manipulation *n.* The processing of data by means of programs that accept user commands, offer ways to handle data, and tell the hardware what to do with the data.

data manipulation language *n.* In database management systems, a language that is used to insert data in, update, and query a database. Data manipulation languages are often capable of performing mathematical and statistical calculations that facilitate generating reports. *Acronym:* DML. *See also* structured query language.

data mart *n.* A scaled-down version of a data warehouse that is tailored to contain only information likely to be used by the target group. *See also* data warehouse.

data medium *n.* The physical material on which computer data is stored.

data migration *n.* **1.** The process of moving data from one repository or source, such as a database, to another, usually via automated scripts or programs. Often data migration involves transferring data from one type of computer system to another. **2.** In supercomputing applications, the process of storing large amounts of data off line while making them appear to be on line as disk-resident files.

data mining *n.* The process of identifying commercially useful patterns, problems, or relationships in a database, a Web server, or other computer repository through the use of advanced statistical tools. Some Web sites use data mining to monitor the efficiency of site navigation and to determine changes in the Web site's design based on how consumers are using the site.

data model *n.* A collection of related object types, operators, and integrity rules that form the abstract entity supported by a database management system (DBMS). Thus, one speaks of a relational DBMS, a network DBMS, and so on, depending on the type of data model a DBMS supports. In general, a DBMS supports only one data model as a practical rather than a theoretical restriction.

data network *n.* A network designed for transferring data encoded as digital signals, as opposed to a voice network, which transmits analog signals.

Data Over Cable Service Interface Specification *n. See* DOCSIS.

data-overrun error *n.* An error that occurs when more data is being acquired than can be processed. *See also* bps.

data packet *n. See* packet.

data path *n.* The route that a signal follows as it travels through a computer network.

data point *n.* Any pair of numeric values plotted on a chart.

data processing *n.* **1.** The general work performed by computers. **2.** More specifically, the manipulation of data to transform it into some desired result. *Acronym:* DP. *Also called:* ADP, automatic data processing, EDP, electronic data processing. *See also* centralized processing, decentralized processing, distributed processing.

Data Processing Management Association *n. See* DPMA.

data projector *n.* A device, similar to a slide projector, that projects the video monitor output of a computer onto a screen.

data protection *n.* The process of ensuring the preservation, integrity, and reliability of data. *See also* data integrity.

data rate *n.* The speed at which a circuit or communications line can transfer information, usually measured in bits per second (bps).

data record *n. See* record[1].

data reduction *n.* The process of converting raw data to a more useful form by scaling, smoothing, ordering, or other editing procedures.

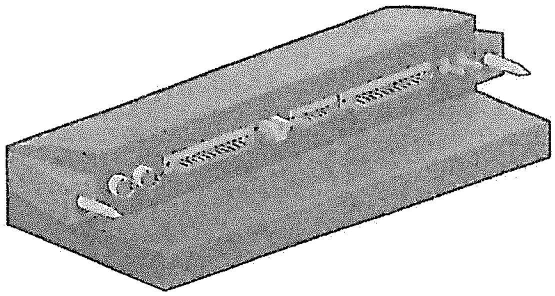
data segment *n.* The portion of memory or auxiliary storage that contains the data used by a program.

Data Service Unit *n. See* DDS.

data set *n.* **1.** A collection of related information made up of separate elements that can be treated as a unit in data handling. **2.** In communications, a modem. *See also* modem.

Data Set Ready *n. See* DSR.

data sharing *n.* The use of a single file by more than one person or computer. Data sharing can be done by physically transferring a file from one computer to another, or, more commonly, by networking and computer-to-computer communications.



Docking station.

DOCSIS *n.* Acronym for Data Over Cable Service Interface Specification. The International Telecommunications Union standard (ITU Recommendation J.112) that specifies functions and internal and external interfaces for high-speed, bidirectional transfer of digital data between cable television networks and subscribers. DOCSIS-compliant equipment ensures interoperability between cable modems and the cable television infrastructure, regardless of manufacturer or provider. Initially developed by a group of cable television providers, including Time Warner and TCI, DOCSIS was designed to support data, video, and rapid Internet access. Data rates are 27 Mbps to 36 Mbps downstream (from the cable network) and 320 Kbps to 10 Mbps upstream (to the cable network). *See also* cable modem. *Compare* IEEE 802.14.

doctype *n.* A declaration at the beginning of an SGML document that gives a public or system identifier for the document type definition (DTD) of the document. *See also* SGML.

document[1] *n.* Any self-contained piece of work created with an application program and, if saved on disk, given a unique filename by which it can be retrieved. Documents are generally thought of as word-processed materials only. To a computer, however, data is nothing more than a collection of characters, so a spreadsheet or a graphic is as much a document as is a letter or report. In the Macintosh environment in particular, a document is any user-created work named and saved as a separate file.

document[2] *vb.* To explain or annotate something, such as a program or a procedure.

documentation *n.* The set of instructions shipped with a program or a piece of hardware. Documentation usually includes necessary information about the type of computer system required, setup instructions, and instructions on the use and maintenance of the product.

document-centric *adj.* Of, pertaining to, or characteristic of an operating system in which the user opens document files and thus automatically invokes the applications (such as word processors or spreadsheet programs) that process them. Many graphical user interfaces, such as the Macintosh Finder, as well as the World Wide Web, are document-centric. *Compare* application-centric.

Document Content Architecture *n. See* DCA (definition 1).

Document Content Description *n. See* DCD (definition 2).

document file *n.* A user-created file that represents the output of a program. *Also called:* data file. *Compare* program file.

document image processing *n.* A system for storing and retrieving information for an enterprise in the form of bitmapped images of paper documents input with a scanner rather than in the form of text and numeric files. Document image processing takes more memory than purely electronic data processing, but it more readily incorporates signatures, drawings, and photographs and can be more familiar to users without computer training. *See also* paperless office.

Document Interchange Architecture *n. See* DIA.

document management *n.* The full spectrum of electronic document creation and distribution within an organization.

document management system *n.* A server-based network facility designed for the storage and handling of an organization's documents. A document management system, or DMS, is built around a central library known as a repository and typically supports controlled access, version tracking, cataloging, search capabilities, and the ability to check documents in and out electronically. The open interface specification known as ODMA (Open Document Management API) enables desktop applications that support ODMA to interface with a DMS so that users can access and manage documents from within their client applications. *Acronym:* DMS. *Also called:* EDMS, electronic document management system.

Document Object Model *n.* A World Wide Web Consortium specification that describes the structure of dynamic HTML and XML documents in a way that allows them to be manipulated through a Web browser. In the Document Object Model, or DOM, a document is presented as a logical structure rather than as a collection of

D

Appendix D

PACKETCABLE™

Built on top of the industry's highly successful DOCSIS® cable modem infrastructure, PacketCable™ networks use Internet protocol (IP) technology to enable a wide range of multimedia services, such as IP telephony, multimedia conferencing, interactive gaming, and general multimedia applications.

Feedback

Appendix E

PacketCable™ 1.0 Architecture Framework Technical Report

PKT-TR-ARCH-V01-991201

Notice

Abstract

This technical report describes the architecture framework for PacketCable™ networks including all major system components and network interfaces necessary for delivery of PacketCable services. The intended audience for this document includes developers of equipment intended to be conformant to PacketCable specifications, and network architects who need to understand the overall PacketCable architecture framework.

Document Status Sheet

Document Control Number:	PKT-TR-ARCH-V01-991201
Document Title:	PacketCable™ 1.0 Architecture Framework Technical Report
Revision History:	D01-991201: release
Date:	December 1, 1999

TABLE OF CONTENTS

1 INTRODUCTION 1

1.1 PacketCable Overview..1

1.2 PacketCable Motivation...1

1.3 PacketCable Project Phasing...2

2 PACKETCABLE 1.0 3

2.1 PacketCable Architecture Framework...4

2.2 PacketCable Zones and Domains..5

2.3 PacketCable 1.0 Specifications 5

2.4 PacketCable 1.0 Design Considerations...6

2.4.1 General Architectural Goals 7
2.4.2 Call Signaling 7
2.4.3 Quality of Service..8
2.4.4 CODEC and Media Stream 9
2.4.5 Device Provisioning and OSS 9
2.4.6 Security...9

3 PACKETCABLE FUNCTIONAL COMPONENTS 10

3.1 Multimedia Terminal Adapter (MTA) 10

3.1.1 MTA Functional Requirements...11
3.1.2 MTA identifiers 11

3.2 Cable Modem (CM) 12

3.3 HFC Access Network...12

3.4 Cable Modem Termination System (CMTS) 12

3.4.1 CMTS Gate...13

3.5 Call Management Server (CMS) 13

3.6 PSTN Gateway 14

3.6.1 Media Gateway Controller (MGC) 15
3.6.2 Media Gateway (MG) 15
3.6.3 Signaling Gateway (SG)..16

3.7 OSS Back Office Components..17

3.7.1 TGS 17
3.7.2 Dynamic Host Configuration Protocol Server (DHCP) 18
3.7.3 Domain Name System Server (DNS) 18
3.7.4 Trivial File Transfer Protocol Server or HyperText Transfer Protocol Server (TFTP or HTTP)..18
3.7.5 SYSLOG Server (SYSLOG)...18
3.7.6 Record Keeping Server (RKS) 18

3.8 Announcement Server (ANS)...18

3.8.1 Announcement Controller (ANC)..19

3.8.2 Announcement Player (ANP) 19

4 PROTOCOL INTERFACES 20

4.1 Call Signaling Interfaces 20

4.1.1 Network-based Call Signaling (NCS) Framework 21
4.1.2 PSTN Signaling Framework 22

4.2 Media Streams 23

4.3 MTA Device Provisioning 25

4.4 SNMP Element Management Layer Interfaces 26

4.5 Event Messages Interfaces 26

4.5.1 Event Message Framework 26

4.6 Quality-of-Service (QoS) 28

4.6.1 QoS Framework 28
4.6.2 Layer Two vs. Layer Four MTA QoS Signaling 30
4.6.3 Dynamic Quality-of-Service 31

4.7 Announcement Services 33

4.7.1 ANS Physical vs. Logical configuration 34

4.8 Security 34

4.8.1 Overview 34
4.8.2 Device Provisioning Security 38

5 NETWORK DESIGN CONSIDERATIONS 41

5.1 Time Keeping and Reporting Issues 41

5.2 Timing for Playout Buffer Alignment with Coding Rate 41

5.3 IP Addressing 41

5.4 Dynamic IP Addressing Assignment 42

5.5 FQDN Assignment 43

5.6 Priority Marking of Signaling and Media Stream Packets 43

5.7 Fax Support 44

5.8 Analog Modem Support 45

6 FUTURE CONSIDERATIONS 46

APPENDIX A. ACKNOWLEDGEMENTS 47

APPENDIX B. REFERENCES 48

APPENDIX C. GLOSSARY 51

APPENDIX D. EXAMPLE DELAY BUDGETS 61

Figures

- Figure 1. PacketCable Reference Architecture 4
- Figure 2. Zones and Administrative Domains... 5
- Figure 3. PacketCable Component Reference Model 10
- Figure 4. E-MTA Conceptual Functional Architecture 12
- Figure 5. Call Signaling Interfaces 20
- Figure 6. RTP Media Stream Flows in a PacketCable Network 23
- Figure 7. RTP Packet Format 24
- Figure 8. PacketCable Provisioning Interfaces...25
- Figure 9. Representative Event Messages Architecture..27
- Figure 10. Event Message Interfaces 27
- Figure 11. PacketCable QoS Signaling Interfaces 28
- Figure 12. Annoucement Services Components and Interfaces..............................33
- Figure 13. PacketCable Security Interfaces 36

Tables

- Table 1 PacketCable 1.0 Specifications and Reports 6
- Table 2. Call Signaling Interfaces 21
- Table 3. Device Provisioning Interfaces 25
- Table 4. Event Message Interfaces...27
- Table 5. QoS Interfaces for Standalone and Embedded MTAs 29
- Table 6. QoS Interfaces 29
- Table 7. Announcement Interfaces 34
- Table 8. Security Interfaces 37

1 INTRODUCTION

1.1 PacketCable Overview

PacketCable™ is a project conducted by Cable Television Laboratories, Inc. (CableLabs®) and its member companies. The PacketCable project is aimed at defining interface specifications that can be used to develop interoperable equipment capable of providing packet-based voice, video and other high-speed multimedia services over hybrid fiber coax (HFC) cable systems utilizing the DOCSIS protocol. PacketCable utilizes a network superstructure that overlays the two-way data-ready broadband cable access network. While the initial PacketCable offering will be packet-based voice communications for existing and new cable subscribers, the long-term project vision encompasses a large suite of packet-based capabilities.

The objective of the PacketCable Architecture Technical Report is to provide a high level reference framework that identifies the functional components and defines the interfaces necessary to implement the capabilities detailed in the individual PacketCable specifications as listed in section 2.3.

1.2 PacketCable Motivation

The emergence of the Internet Protocol (IP) as the standard transport for packet data networks has enabled a revolution in communications service and applications. This online revolution is evidenced by the widespread use of email, chat groups, music, video, and the exponential growth of the World Wide Web, for entertainment, information exchange, online commerce, and a wide range of the new and innovative services. New classes of IP based information appliances are also emerging, including multimedia personal computers, IP based set top boxes, and IP based voice and video phones.

In recent years the growth of a worldwide IP based data network, coupled with the exponential growth in the number of households that have online access, have resulted in an enabling environment for offering integrated voice and data services over a common broadband cable access network and IP transport backbone. While the initial application of IP voice technology was for toll bypass services, particularly high-cost international toll service, the technology has now matured to the point where it is feasible to offer IP-based voice communications services comparable to those offered by telecommunications carriers on the PSTN.

With the success of the DOCSIS standardization effort, the QoS enhancements of DOCSIS 1.1, and the acceleration of major cable system upgrades for two way capacity, the infrastructure is in place for development and deployment of packetized voice and video applications. These applications can be deployed with minimal incremental cost, providing a technically distinctive and cost-effective alternative for subscribers' voice communications needs, as well as a platform for introducing the next generation of voice and other real time multimedia services.

1.3 PacketCable Project Phasing

The PacketCable architecture is designed to be a robust, complete, end-end broadband architecture that supports voice, video, and other multimedia services. The architecture is capable of supporting millions of subscribers over multiple cable operator networks.

It is understood that the initial focus of the PacketCable architecture must support the time-to-market business considerations of CableLabs Member Companies for deploying packet-based services. Going forward, the PacketCable architecture must continue to evolve to meet Member business requirements and to accommodate advances resulting from the maturing of IP-based technology. The PacketCable project will release specifications that define this architecture in a phased approach according to technical feasibility and business priority. As new PacketCable specifications are released, they will complement the previously released specifications.

From time to time this document refers to the voice communications capabilities of a PacketCable network in terms of "IP Telephony." The legal/regulatory classification of IP-based voice communications provided over cable networks and otherwise, and the legal/regulatory obligations, if any, borne by providers of such voice communications, are not yet fully defined by appropriate legal and regulatory authorities. Nothing in this document is addressed to, or intended to affect, those issues. In particular, while this document uses standard terms such as "call," "call flow," "telephony," etc., it should be recalled that while a PacketCable network performs activities analogous to these PSTN functions, the manner by which it does so differs considerably from the manner in which they are performed in the PSTN by telecommunications carriers, and that these differences may be significant for legal/regulatory purposes. Moreover, while reference is made here to "IP Telephony," it should be recognized that this term embraces a number of different technologies and network architecture, each with different potential associated legal/regulatory obligations. No particular legal/regulatory consequences are assumed or implied by the use of this term.

2 PACKETCABLE 1.0

'PacketCable 1.0' is a CableLabs definition for the first release of specifications that define the PacketCable reference architecture.

In this version of the architecture framework, the emphasis is on specification of the subscriber environment and its interface requirements to the PacketCable network including the DOCSIS HFC access network, Call Management Server, media servers, PSTN gateway, and MTA device provisioning components. The requirements for these functional components and the standardized interfaces between components are defined in detail in the PacketCable 1.0 specifications. In later versions, additional component interfaces will be defined.

PacketCable 1.0 consists of a variety of functional components, each of which must work in harmony to create a consistent and cost-effective delivery mechanism for packet-based services. This distributed architecture allows incremental development and deployment of new features and services, leaving room for implementation flexibility and product innovation. A key focus of the initial PacketCable release is the definition of low-cost subscriber equipment and a network architecture that supports low cost packet-based services. Follow-on phases of this project will continue to add support for advanced subscriber-side functionality. This may require evolution in the PacketCable call signaling, QoS security, provisioning, and billing protocols.

PacketCable allows the use of proprietary vendor-specific solutions for interfaces not defined in specifications. Over time, as additional PacketCable interface protocols are defined, these proprietary interfaces will need to be updated in order to be compliant with PacketCable specifications.

2.1 PacketCable Architecture Framework

At a very high level, the PacketCable 1.0 architecture contains three networks: the "DOCSIS HFC Access Network", the "Managed IP Network" and the PSTN. The Cable Modem Termination System (CMTS) provides connectivity between the "DOCSIS HFC Access Network" and the "Managed IP Network". Both the Signaling Gateway (SG) and the Media Gateway (MG) provide connectivity between the "Managed IP Network" and the PSTN. The reference architecture for PacketCable 1.0 is shown in Figure 1.

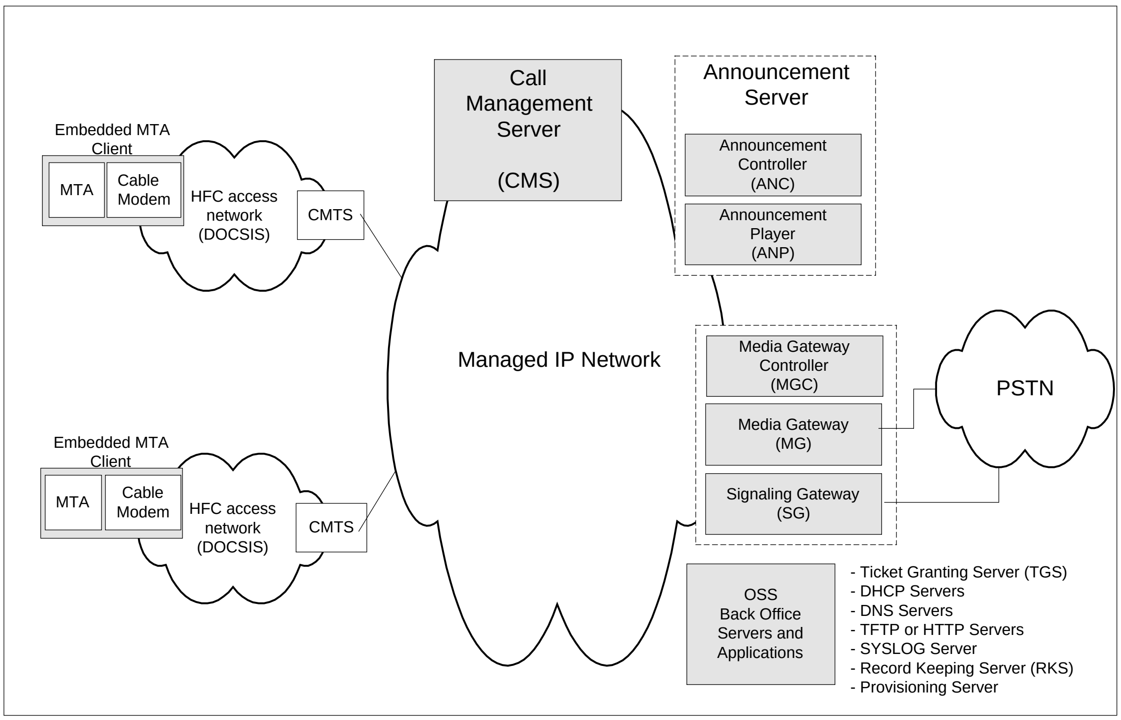


Figure 1. PacketCable Reference Architecture

The DOCSIS HFC access network provides high-speed, reliable, and secure transport between the customer premise and the cable headend. This access network may provide all DOCSIS 1.1 capabilities including Quality of Service. The DOCSIS HFC access network includes the following functional components: the Cable Modem (CM), Multi-media Terminal Adapter (MTA), and the Cable Modem Termination System (CMTS).

The Managed IP network serves several functions. First, it provides interconnection between the basic PacketCable functional components responsible for signaling, media, provisioning, and quality of service establishment. In addition, the managed IP network provides long-haul IP connectivity between other Managed IP and DOCSIS HFC networks. The Managed IP network includes the following functional components: Call Management Server (CMS), Announcement Server (ANS), several Operational Support System (OSS) back-office servers, Signaling Gateway (SG), Media Gateway (MG), and Media Gateway Controller (MGC).

The individual network components that are shown in Figure 1 are described in detail in Section 3.

2.2 PacketCable Zones and Domains

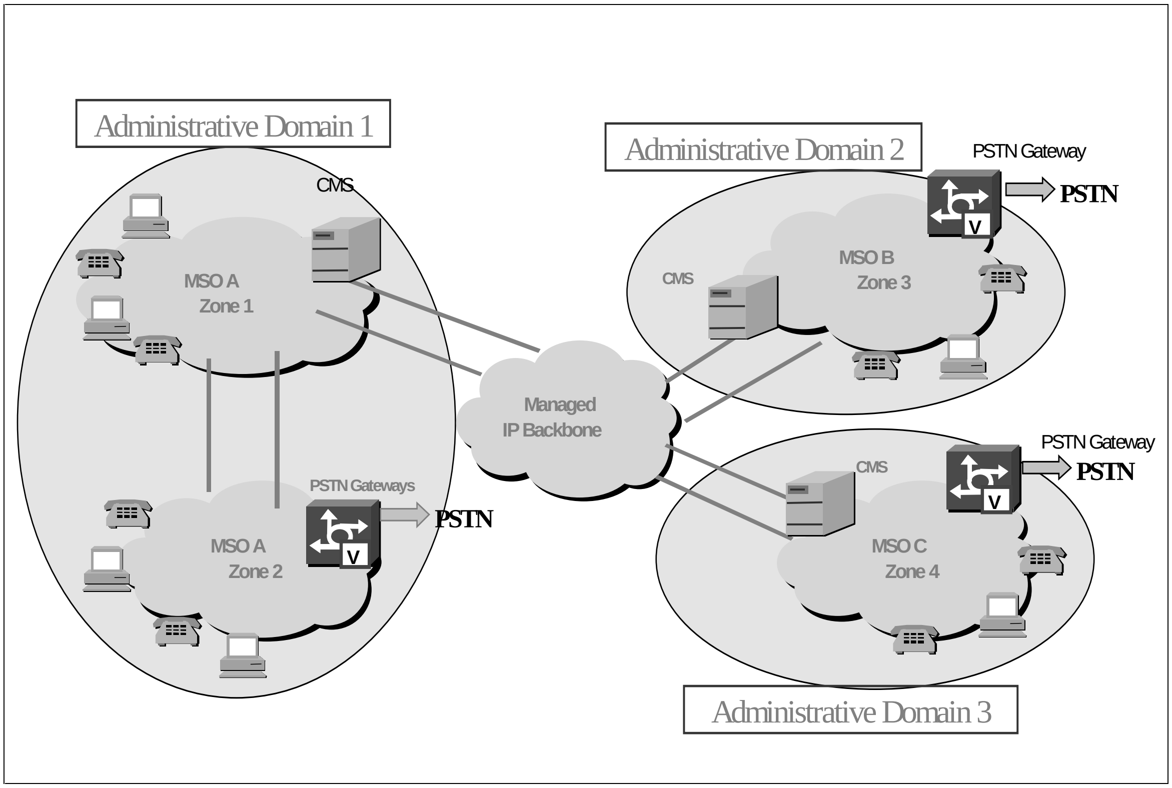


Figure 2. Zones and Administrative Domains

A PacketCable zone consists of the set of MTAs in one or more DOCSIS HFC access networks that are managed by a single functional CMS as shown in Figure 2. Interfaces between functional components within a single zone are defined in the PacketCable 1.0 specifications. Interfaces between zones (e.g., CMS-CMS) have not been defined and will be addressed in future phases of the PacketCable architecture.

A PacketCable domain is made up of one or more PacketCable zones that are operated and managed by a single administrative entity. A PacketCable domain may also be referred to as an administrative domain. Interfaces between domains have not defined in PacketCable 1.0 and will be addressed in future phases of the PacketCable architecture.

2.3 PacketCable 1.0 Specifications

PacketCable 1.0 consists of the eleven Specifications and three Technical Reports shown in Table 1.

Table 1 PacketCable 1.0 Specifications and Reports

PacketCable Specification Reference Number	Specification Name
PKT-SP-CODEC	Audio/Video Codecs
PKT-SP-DQOS	Dynamic Quality-of-Service
PKT-SP-EC-MGCP	Network-Based Call Signaling (NCS)
PKT-SP-EM	Event Messages
PKT-SP-ISTP	Internet Signaling Transport Protocol (ISTP)
PKT-SP-MIBS	MIB Framework
PKT-SP-MIBS-MTA	MTA MIB
PKT-SP-MIBS-NCS	NCS MTA MIB
PKT-SP-PROV	MTA Device Provisioning
PKT-SP-SEC	Security
PKT-SP-TGCP	PSTN Gateway Call Signaling Protocol
PacketCable Technical Report Reference Number	**Technical Report Name**
PKT-TR-CF	Call Flows
PKT-TR-ARCH	Architecture Framework
PKT-TR-OSS	OSS Overview

2.4 PacketCable 1.0 Design Considerations

In order to enable real-time multimedia communications across the cable network infrastructure, PacketCable specifications define protocols in the following areas:

- Call Signaling
- Quality of Service
- Media Stream Transport and Encoding
- Device Provisioning
- Event Messaging
- Security and Privacy
- Operational Support Systems

This section provides an overview of the high-level design goals and concepts used in developing the specifications that define the PacketCable 1.0 reference architecture. Individual PacketCable specifications should be consulted to obtain detailed protocol requirements for each of these areas.

2.4.1 General Architectural Goals

- Enable voice quality capabilities comparable to or better than the PSTN as perceived by the end-user.
- Provide a network architecture that is scalable and capable of supporting millions of subscribers.
- Ensure the one-way delay for local IP access and IP egress (i.e. excluding the IP backbone network) is less than 45ms.
- Support primary and secondary line residential voice communications capabilities.
- Leverage existing protocol standards. PacketCable strives to specify open, approved industry standards that have been widely adopted in other commercial communication networks. This includes protocols approved by the ITU, IETF, IEEE, Telcordia and other communications standards organizations.
- Leverage and build upon the data transport and Quality of Service capabilities provided by DOCSIS.
- Define an architecture that allows multiple vendors to rapidly develop low-cost interoperable solutions to meet Member time-to-market requirements.
- Ensure that the probability of blocking a call can be engineered to be less than 1% during the High Day Busy Hour (HDBH)
- Ensure that call cutoffs and call defects can be engineered to be less than 1 per 10,000 completed calls.
- Support modems (up to V.90 56 kb/s) and fax (up to 14.4 kbps)
- Ensure that frame slips due to unsynchronized sampling clocks or due to lost packets occur less than 0.25 per minute.

2.4.2 Call Signaling

- Define a network-based signaling paradigm.
- Provide end-to-end call signaling for the following call models:
    - calls that originate from the PSTN and terminate on the cable network
    - calls that originate on the cable network and terminate on the cable network within a single PacketCable zone
    - calls that originate from the cable network and terminate on the PSTN
- Provide signaling to support custom calling features such as:
    - Call Waiting
    - Cancel Call Waiting
    - Call Forwarding (no-answer, busy, variable)
    - Three-way Calling

  - Voice mail Message Waiting Indicator
- Provide signaling to support Custom Local Area Signaling Services (CLASS) features such as:
  - Calling Number Delivery
  - Calling Name Delivery
  - Calling Identity Delivery On Call Waiting
  - Calling Identity Delivery Blocking
  - Anonymous Call Rejection
  - Automatic Callback
  - Automatic Recall
  - Distinctive Ringing/Call Waiting
  - Customer Originated Trace
- Support a signaling paradigm consistent with existing IP telephony standards for use within a cable operator's PacketCable network and when connecting to the PSTN.
- Ability to direct dial any domestic or international telephone number (E.164 address)
- Ability to receive a call from any domestic or international telephone number supported by the PSTN.
- Ensure that a new subscriber retains current phone number via Local Number Portability (LNP)
- Ability to use the IXC of choice for intra-LATA toll (local toll) and inter-LATA (long distance) calls. This includes pre-subscription and "dial-around" (10-1X-XXX).
- Support Call Blocking/Call Blocking Toll restrictions, (e.g. blocking calls to 900-, 976-, etc.)

2.4.3 Quality of Service

- Provide a rich set of policy mechanisms to provide and manage QoS for PacketCable services over the access network.
- Provide admission control mechanisms for both upstream and downstream directions.
- Allow dynamic changes in QoS in the middle of PacketCable calls.
- Enable transparent access to all of the QoS mechanisms defined in DOCSIS 1.1. PacketCable clients need not be aware of specific DOCSIS QoS primitives and parameters.

- Minimize and prevent abusive QoS usage including theft-of and denial-of service attacks. Ensure QoS policy is set and enforced by trusted PacketCable network elements.
- Provide a priority mechanism for 911 and other priority based signaling services.

2.4.4 CODEC and Media Stream

- Minimize the effects that latency, packet-loss, and jitter have on voice-quality in the IP telephony environment.
- Define a minimum set of audio codecs that must be supported on all PacketCable endpoint devices (MTAs). Evaluation criteria for mandatory codecs are selected as those most efficient with respect to voice quality, bandwidth utilization, and implementation complexity.
- Accommodate evolving narrow-band and wide-band codec technologies.
- Specify echo cancellation and voice activity detection mechanisms.
- Support for transparent, error-free DTMF transmission and detection.
- Support terminal devices for the deaf and hearing impaired.
- Provide mechanisms for codec switching when fax and modem services are required.

2.4.5 Device Provisioning and OSS

- Support dynamic and static provisioning of customer premise equipment (MTA and Cable Modem).
- Provisioning changes should not require reboot of MTA.
- Allow dynamic assignment and management of IP addresses for subscriber devices
- Ensure that real-time provisioning and configuration of MTA software does not adversely affect subscriber service.
- Define SNMP MIBs for managing customer premise equipment (MTA).

2.4.6 Security

- Enable residential voice capabilities with the same or higher level of perceived privacy as in the PSTN.
- Provide protection against attacks on the MTA.
- Protect the MSO from various denial of service, network disruption and theft of service attacks.
- Design considerations include confidentiality, authentication, integrity, non-repudiation and access control.

3 PACKETCABLE FUNCTIONAL COMPONENTS

This section describes the functional components present in a PacketCable network. Component descriptions are not intended to define or imply product implementation requirements but instead to describe the functional role of each of these components in the reference architecture. Note that specific product implementations may combine functional components as needed. Not all components are required to be present in a PacketCable Network.

The PacketCable architecture contains trusted and untrusted network elements. Trusted network elements are typically located within a Cable Operator's managed backbone network. Untrusted network elements, such as the CM and MTA, are typically located within the subscriber's home and outside of the MSO's facility.

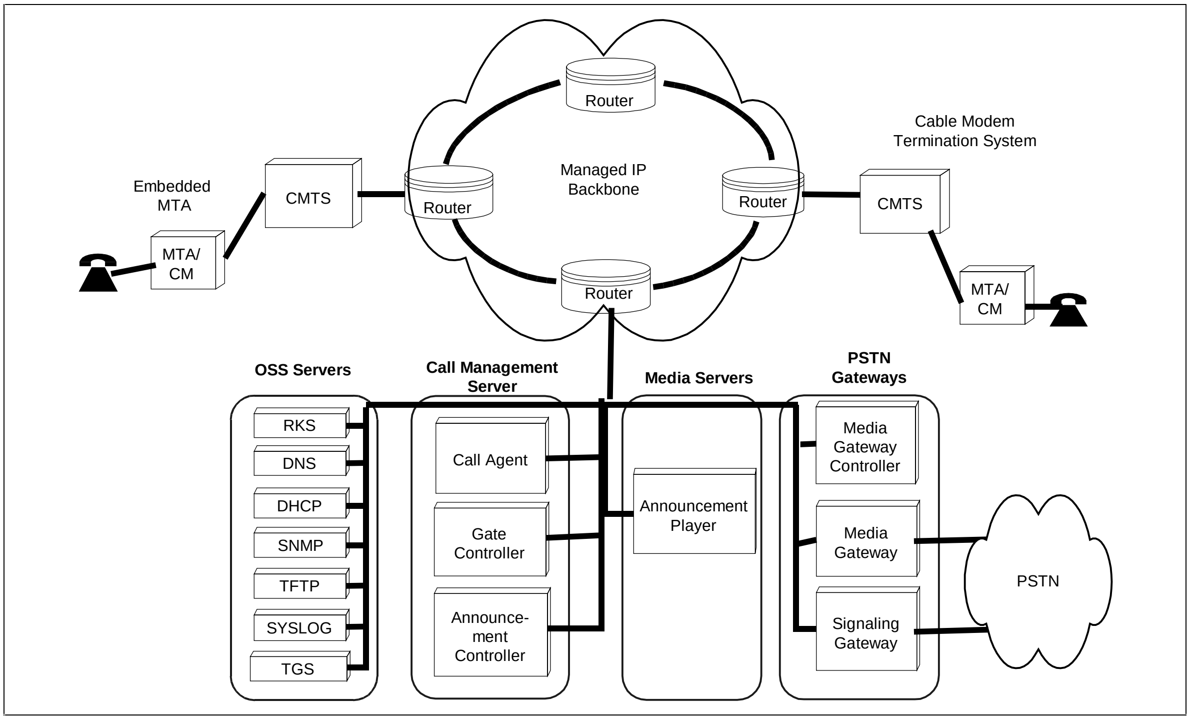


Figure 3. PacketCable Component Reference Model

3.1 Multimedia Terminal Adapter (MTA)

An MTA is a PacketCable client device that contains a subscriber-side interface to the subscriber's CPE (e.g., telephone) and a network-side signaling interface to call control elements in the network. An MTA provides codecs and all signaling and encapsulation functions required for media transport and call signaling.

MTAs reside at the customer site and are connected to other PacketCable network elements via the HFC access network (DOCSIS). PacketCable 1.0 MTAs are required to support the Network Call Signaling (NCS) protocol.

An embedded MTA (E-MTA) is a single hardware device that incorporates a DOCSIS 1.1 cable modem as well as a PacketCable MTA component. Figure 4 shows a representative functional diagram of an E-MTA.

PacketCable 1.0 specifications only require support for embedded MTAs. Throughout this report, unless otherwise noted, the term MTA refers to an embedded MTA.

3.1.1 MTA Functional Requirements

An MTA is responsible for the following functionality:

- NCS call signaling with the CMS
- QoS signaling with the CMS and the CMTS
- Authentication, confidentiality and integrity of some messages between the MTA and other PacketCable network elements
- Mapping media streams to the MAC services of the DOCSIS access network
- Encoding/decoding of media streams
- Providing multiple audio indicators to phones, such as ringing tones, call-waiting tones, stutter dial tone, dial tone, etc.
- Standard PSTN analog line signaling for audio tones, voice transport, caller-id signaling, DTMF, and message waiting indicators
- The G.711 audio codec
- One or more RJ11 analog interface(s) as defined by Bellcore TR-909

Additional MTA functionality is defined in other PacketCable specifications such as NCS Signaling [5], Dynamic Quality-of-Service [4], Audio-Video Codecs [3], MIBS [8][9], and MTA Device Provisioning [12].

3.1.2 MTA identifiers

The following identifiers characterize the E-MTA:

- An embedded MTA has two MAC addresses, one for the cable modem and one for the MTA.
- An embedded MTA has two IP addresses, one for the cable modem and one for the MTA.
- An embedded MTA has two Fully Qualified Domain Names (FQDN), one for the cable modem and one for the MTA
- At least one telephone number per configured physical port
- Device capabilities
- The MTA's associated CMS

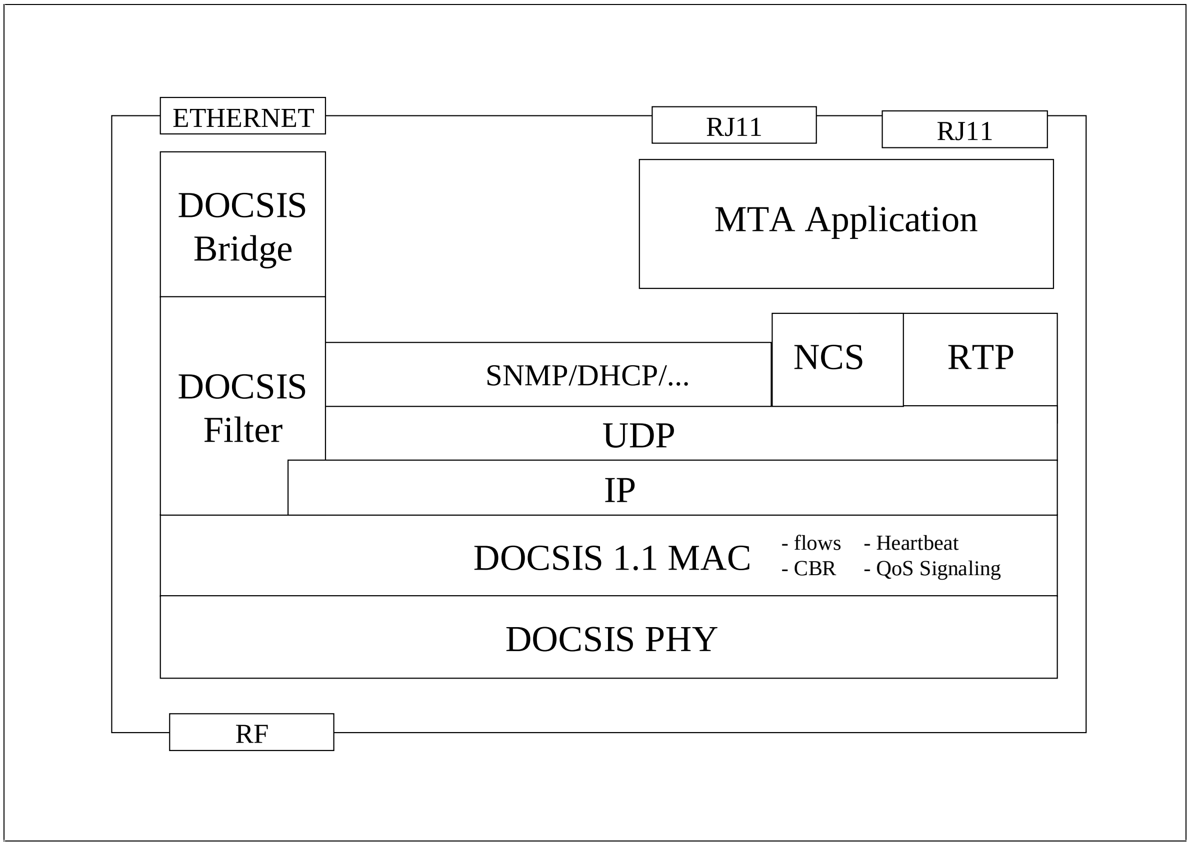


Figure 4. E-MTA Conceptual Functional Architecture

3.2 Cable Modem (CM)

The cable modem (CM) is a network element that is defined in the DOCSIS [19]. The CM is a modulator/demodulator residing on the customer premise that provides data transmission over the cable network using the DOCSIS protocol. In PacketCable, the CM plays a key role in handling the media stream and provides services such as classification of traffic into service flows, rate shaping, and prioritized queuing.

3.3 HFC Access Network

PacketCable-based services are carried over the Hybrid Fiber/Coax (HFC) access network. The access network is a bi-directional, shared-media system that consists of the Cable Modem (CM), the Cable Modem Termination System (CMTS), and the DOCSIS MAC and PHY access layers.

3.4 Cable Modem Termination System (CMTS)

The CMTS provides data connectivity and complimentary functionality to cable modems over the HFC access network (DOCSIS). It also provides connectivity to wide area networks. The CMTS is located at the cable television system head-end or distribution hub.

The CMTS is responsible for the following functions:

- Providing the required QoS to the CM based upon policy configuration.
- Allocating upstream bandwidth in accordance to CM requests and network QoS policies.
- Classifying each arriving packet from the network side interface and assigning it to a QoS level based on defined filter specifications.
- Policing the TOS field in received packets from the cable network to enforce TOS field settings per network operator policy.
- Altering the TOS field in the downstream IP headers based on the network operator's policy.
- Performing traffic shaping and policing as required by the flow specification.
- Forwarding downstream packets to the DOCSIS network using the assigned QoS.
- Forwarding upstream packets to the backbone network devices using the assigned QoS.
- Converting and classifying QoS Gate parameters into DOCSIS QoS parameters.
- Signaling and reserving any backbone QoS necessary to complete the service reservation.
- Recording usage of resources per call using PacketCable Event Messages.

3.4.1 CMTS Gate

The CMTS Gate is a functional component of the CMTS that performs traffic classification and enforces QoS policy on media streams as directed by the Gate Controller (GC).

3.5 Call Management Server (CMS)

The Call Management Server provides call control and signaling related services for the MTA, CMTS, and PSTN gateways in the PacketCable network. The CMS is a trusted network element that resides on the managed IP portion of the PacketCable network.

A PacketCable 1.0 CMS consists of the following logical PacketCable components.

Call Agent (CMS/CA) – Call Agent is a term that is often used interchangeably with CMS, especially in the MGCP. In PacketCable, the Call Agent (CA) refers to the control component of the CMS that is responsible for providing signaling services using the NCS protocol to the MTA. In this context, Call Agent responsibilities include but are not limited to:

- Implementing call features
- Maintaining call progress state
- The use of codecs within the subscriber MTA device

- Collecting and pre-processing dialed digits
- Collecting and classifying user actions

Gate Controller (CMS/GC) – The Gate Controller (GC) is a logical QoS management component within the CMS that coordinates all quality of service authorization and control. Gate Controller functionality is defined in the Dynamic Quality of Service specification.

The CMS may also contain the following logical components:

Media Gateway Controller - The MGC is logical signaling management component used to control PSTN Media Gateways. The MGC function is defined in detail later in this section.

Announcement Controller - The ANC is a logical signaling management component used to control network announcement servers. The ANC function is defined in detail in Section 3.8.

The CMS may also provide the following functions:

- Call management and CLASS features
- Directory Services and Address translation
- Call routing
- Record usage of local number portability services
- Zone-to-Zone call signaling and QoS admission control

For the purposes of this specification, protocols that implement the functionality of the CMS are specified as terminating at the CMS – actual implementations may distribute the functionality in one or more servers that sit “behind” the Call Management Server.

3.6 PSTN Gateway

PacketCable allows MTA’s to inter-operate with the current PSTN through the use of PSTN Gateways.

In order to enable operators to minimize cost and optimize their PSTN interconnection arrangements, the PSTN Gateway is decomposed into three functional components:

- **Media Gateway Controller (MGC)** – The MGC maintains the call state and controls the overall behavior of the PSTN gateway.
- **Signaling Gateway (SG)** – The SG provides a signaling interconnection function between the PSTN SS7 signaling network and the IP network.
- **Media Gateway (MG)** – The MG terminates the bearer paths and transcodes media between the PSTN and IP network.

3.6.1 Media Gateway Controller (MGC)

The Media Gateway Controller (MGC) receives and mediates call-signaling information between the PacketCable network and the PSTN. It maintains and controls the overall call state for calls requiring PSTN interconnection.

The MGC controls the MG by instructing it to create, modify, and delete connections that support the media stream over the IP network. The MGC also instructs the MG to detect and generate events and signals such as continuity test tones for ISUP trunks, or MF signaling for MF trunks. Each trunk is represented as an endpoint.

The following is a list of functions performed by the Media Gateway Controller:

- **Call Control Function** – maintains and controls the overall PSTN Gateway call state for the portion of a call that traverses the PSTN Gateway. The function interfaces with external PSTN elements as needed for PSTN Gateway call control, e.g., by generating TCAP queries.
- **PacketCable Signaling** – terminates and generates the call signaling from and to the PacketCable side of the network.
- **MG Control** – The MG Control function exercises overall control of endpoints in the Media Gateway:
    - Event Detection instructs the MG to detect events, e.g., in-band tones and seizure state, on the endpoint and possibly connections.
    - Signal Generation instructs the MG to generate in-band tones and signals on the endpoint and possibly connections.
    - Connection Control instructs the MG on the basic handling of connections from and to endpoints in the MG.
    - Attribute Control instructs the MG regarding the attributes to apply to an endpoint and/or connection, e.g., encoding method, use of echo cancellation, security parameters, etc.
- **External Resource Monitoring –** maintains the MGC's view of externally visible MG resources and packet network resources, e.g. endpoint availability.
- **Call Routing –** makes call routing decisions.
- **Security –** ensures that any entity communicating with the MGC adheres to the security requirements.
- **Usage Recording via Event Messages –** records usage of resources per call.

3.6.2 Media Gateway (MG)

The Media Gateway provides bearer connectivity between the PSTN and the PacketCable IP network. Each bearer is represented as an endpoint and the MGC instructs the MG to set-up and control media connections to other endpoints on the PacketCable network. The MGC also instructs the MG to detect and generate events and signals relevant to the call state known to the MGC.

3.6.2.1 Media Gateway Functions

The following is a list of functions performed by the Media Gateway:

- Terminates and controls physical circuits in the form of bearer channels from the PSTN.
- Discriminates between media and Channel Associated In-band signaling information from the PSTN circuit.
- Detects events on endpoints and connections as requested by the MGC. This includes events needed to support in-band signaling, e.g., MF.
- Generates signals on endpoints and connections, e.g., continuity tests, alerting, etc. as instructed by the MGC. This includes signals needed to support in-band signaling.
- Creates, modifies, and deletes connections to and from other endpoints as instructed by the MGC.
- Controls and assigns internal media processing resources to specific connections upon receipt of a general request from the Media Gateway Controller.
- Performs media transcoding between the PSTN and the PacketCable network. This includes all aspect of the transcoding such as codecs, echo cancellation, etc.
- Ensures that any entity communicating with the MG adheres to the security requirements.
- Determines usage of relevant resources and attributes associated with those resources, e.g., number of media bytes sent and received.
- Reports usage of resources to the MGC.

3.6.3 Signaling Gateway (SG)

The Signaling Gateway function sends and receives circuit-switched network signaling at the edge of the PacketCable network. For PacketCable 1.0, the signaling gateway function only supports non-facility associated signaling in the form of SS7. Facility associated signaling in the form of MF is supported by the MG function directly.

3.6.3.1 SS7 Signaling Gateway Functions

The following is a list of functions performed by the Signaling Gateway function:

- Terminates physical SS7 signaling links from the PSTN (A, F links).
- Implements security features, to ensure that the Gateway security is consistent with PacketCable and SS7 network security requirements.
- Terminates Message Transfer Part (MTP) level 1, 2 and 3.
- Implements MTP network management functions as required for any SS7 signaling point.

- Performs ISUP Address Mapping to support flexible mapping of Point Codes (both Destination Point Code and Origination Point Code) and/or Point Code/CIC code combination contained within SS7 ISUP messages to the appropriate Media Gateway Controller (MGC) (either a domain name or an IP address). The addressed MGC will be responsible for controlling the Media Gateway, which terminates the corresponding trunks.
- Performs TCAP Address Mapping to map Point Code/Global Title/SCCP Subsystem Number combinations within SS7 TCAP messages to the appropriate Media Gateway Controller or Call Management Server.
- Provides mechanism for certain trusted entities ("TCAP Users") within the PacketCable network, such as Call Agents, to query external PSTN databases via TCAP messages sent over the SS7 network.
- Implements the transport protocol required to transport the signaling information between the Signaling Gateway and the Media Gateway Controller.

3.7 OSS Back Office Components

The OSS back office contains business, service, and network management components supporting the core business processes. As defined by the ITU TMN framework, the main functional areas for OSS are fault management, performance management, security management, accounting management, and configuration management. These topics are covered in detail in the PacketCable OSS Framework Technical Report [15].

PacketCable 1.0 defines a limited set of OSS functional components and interfaces to support MTA device provisioning and Event Messaging to carry billing information.

3.7.1 TGS

For PacketCable, the term TGS (Ticket Granting Server) is utilized for a Kerberos server. The Kerberos protocol with the public key PKINIT extension is used for key management on the MTA-CMS interface [37].

The TGS grants Kerberos tickets to the MTA. A ticket contains information used to set up authentication, privacy, integrity and access control for the call signaling between the MTA and the CMS. This ticket is issued in three different scenarios.

- During device provisioning, the MTA requests a ticket from the TGS. It is strongly recommended that the MTA save Kerberos tickets in persistent storage. In the case when the MTA reboots, if the saved ticket is still valid, then the MTA will not need to execute the PKINIT to request a new ticket from the TGS.
- In normal operation, each time a ticket expires, the MTA will request a new ticket during the grace period from the TGS. Note: In the case of power failure in the CMS, the MTA will no longer be associated with this CMS. When this CMS restarts it will request "wake up" information from the MTA. If the ticket the MTA currently holds is beyond the expiration time, often referred to as a stale ticket, the MTA will request a new ticket from the TGS. If the MTA is still

holding a valid ticket then it should send this ticket to the CMS without requesting a new one from the TGS.

- When the TGS is not available on the network and the MTA can not get a new ticket during the grace period, the MTA must hold on to the current, but stale ticket until a TGS is available to grant a new ticket. The request from the MTA during this condition is specified in the PacketCable Security specification [13].

3.7.2 Dynamic Host Configuration Protocol Server (DHCP)

The DHCP server is a back office network element used during the MTA device provisioning process to dynamically allocate IP addresses and other client configuration information.

3.7.3 Domain Name System Server (DNS)

The DNS server is a back office network element used to map between ASCII domain names and IP addresses.

3.7.4 Trivial File Transfer Protocol Server or HyperText Transfer Protocol Server (TFTP or HTTP)

The TFTP Server is a back office network element used during the MTA device provisioning process to download configuration files to the MTA. An HTTP Server may be used instead of a TFTP server to download configuration files to the MTA.

3.7.5 SYSLOG Server (SYSLOG)

The SYSLOG server is a back office network element used to collect events such as traps and errors from an MTA.

3.7.6 Record Keeping Server (RKS)

The RKS is a trusted network element component that receives PacketCable Event Messages from other trusted PacketCable network elements such as the CMS, CMTS, and MGC. The RKS also, at a minimum, is a short-term repository for PacketCable Event Messages. The RKS may assemble the Event Messages into coherent sets or Call Detail Records (CDRs), which are then made available to other back office systems such as billing, fraud detection, and other systems.

3.8 Announcement Server (ANS)

An Announcement Server is a network component that manages and plays informational tones and messages in response to events that occur in the network. An Announcement Server (ANS) is a logical entity composed of an Announcement Controller (ANC) and an Announcement player (ANP).

3.8.1 Announcement Controller (ANC)

The ANC initiates and manages all announcement services provided by the Announcement Player. The ANC requests the ANP to play announcements based on call state as determined by the CMS. When information is collected from the end-user by the ANP, the ANC is responsible for interpreting this information and manage the session accordingly. Hence, the ANC may also manage call state.

3.8.2 Announcement Player (ANP)

The Announcement Player is a media resource server. It is responsible for receiving and interpreting commands from the ANC and for delivering the appropriate announcement(s) to the MTA. The ANP also is responsible for accepting and reporting user inputs (e.g., DTMF tones). The ANP functions under the control of the ANC.

4 PROTOCOL INTERFACES

Protocol specifications have been defined for most of the component interfaces in the PacketCable architecture. An overview of each protocol interface is provided within this section. The individual PacketCable specifications should be consulted for the complete protocol requirements.

It is possible that some of these interfaces may not exist in a given vendor's product implementation. For example, if several functional PacketCable components are combined then it is possible that some of these interfaces are internal to that component.

4.1 Call Signaling Interfaces

Call signaling requires multiple interfaces within the PacketCable architecture. These interfaces are identified in Figure 5. Each interface in the diagram is labeled, and further described in the subsequent Table 2.

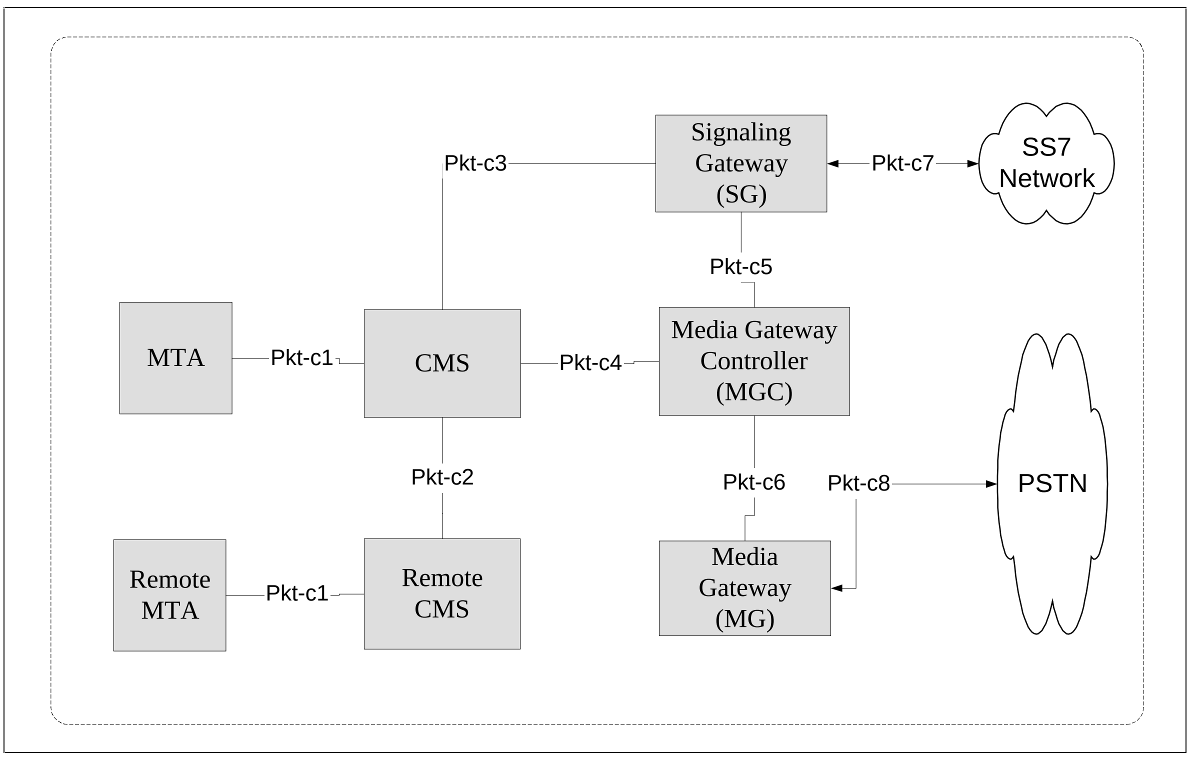


Figure 5. Call Signaling Interfaces

Table 2. Call Signaling Interfaces

Interface	PacketCable Functional Components	Description
Pkt-c1	MTA – CMS	Call signaling messages exchanged between the MTA and CMS using the NCS protocol, which is a profile of MGCP.
Pkt-c2	CMS-CMS	Call signaling messages exchanged between CMS's. The protocol for this interface is undefined in PacketCable 1.0.
Pkt-c3	CMS – SG	Call signaling messages exchanged between CMS and SG using the ISTP/TCAP protocol.
Pkt-c4	CMS – MGC	Call signaling messages exchanged between the CMS and MGC. The protocol for this interface is undefined in PacketCable 1.0
Pkt-c5	SG – MGC	Call signaling messages exchanged between the MGC and SG using the ISTP/ISUP and ISTP/TCAP protocol
Pkt-c6	MGC – MG	Interface for media control of the media gateway and possibly in-band signaling using the TGCP protocol, which is a profile of MGCP, similar to NCS.
Pkt-c7	SG – SS7	The SG terminates physical SS7 signaling links from the PSTN (A, F links). The following protocols are supported: • ISUP User Interface. Provides an SS7 ISUP signaling interface to external PSTN carriers. • TCAP User Interface. Provides mechanism for certain trusted entities ("TCAP Users") within the PacketCable network, such as Call Agents, to query external PSTN databases via TCAP messages sent over the SS7 network.
Pkt-c8	MG – PSTN	This interface defines bearer channel connectivity from the Media Gateway to the PSTN and supports the following call signaling protocols: • In-Band MF Signaling A future version of PacketCable may support ISDN PRI[1].

4.1.1 Network-based Call Signaling (NCS) Framework

The PacketCable Network-Based Call Signaling (NCS) protocol (Pkt-c1) is an extended variant of the IETF's MGCP call signaling protocol. The NCS architecture places call state and feature implementation in a centralized component, the Call Management Server (CMS), and places device control intelligence in the MTA. The MTA passes device events to the CMS, and responds to commands issued from the CMS. The CMS, which may consist of multiple geographically or administratively distributed systems, is responsible for setting up and tearing down calls, providing advanced services [CLASS and custom calling features], performing call authorization, and generating billing event records, etc.

Examples of the partition of function would be for the CMS to instruct the MTA to inform the CMS when the phone goes off hook, and seven DTMF digits have been entered. When this sequence of events occur, the MTA notifies the CMS. The CMS

[1] This function may be viewed as belonging in the Signaling Gateway function.

may then instruct the MTA to create a connection, reserve QoS resources through the access network for the pending voice connection, and also to play a locally generated ringback tone. The CMS in turn communicates with a remote CMS (or MGC) to setup the call. When the CMS detects answer from the far end, it instructs the MTA to stop the ringback tone, activate the media connection between the MTA and the far-end MTA, and begin sending and receiving media stream packets.

By centralizing call state and service processing in the CMS, the service provider is in a position to centrally manage the reliability of the service provided. In addition the service provider gains full access to all software and hardware in the event that a defect that impacts subscriber services occurs. Software can be centrally controlled, and updated in quick debugging and resolution cycles that do not require deployment of field personnel to the customer premise. Additionally, the service provider has direct control over the services introduced and the associated revenue streams associated with such services.

4.1.2 PSTN Signaling Framework

PSTN signaling interfaces are summarized in Table 2 (Pkt-c3 through Pkt-c8). These interfaces provide access to PSTN-based services and to PSTN subscribers from the PacketCable network.

The PacketCable PSTN signaling framework consists of a PSTN gateway that is subdivided into three functional components:

- Media Gateway Controller (MGC)
- Media Gateway (MG)
- Signaling Gateway (SG)

The Media Gateway Controller and Media Gateway are analogous to, respectively, the CMS and MTA in the NCS framework. The Media Gateway provides bearer and in-band signaling connectivity to the PSTN. The Media Gateway Controller implements all the call state and intelligence and controls the operation of the Media Gateway through the TGCP protocol (pkt-c6). This includes creation, modification and deletion of connections as well as in-band signaling information to and from the MG. TGCP is an extended variant of the IETF's MGCP call signaling protocol. The TGCP variant is closely aligned with NCS.

The CMS and the MGC may each send routing queries (e.g., 800 number lookup, LNP lookup) to an SS7 Service Control Point (SCP) via the SG (pkt-c3 and pkt-c5). The MGC, via the SG, also exchanges ISUP signaling with the PSTN's SS7 entities for trunk management and control. The ISTP protocol provides the signaling interconnection service between the PacketCable network call control elements (Call Management Server and Media Gateway Controller) and the PSTN SS7 Signaling network through the SS7 Signaling Gateway. ISTP contains features for initialization; address mapping from the SS7 domain to the IP domain; message delivery for SS7 ISUP and TCAP; congestion management, fault management, maintenance operations; and redundant configuration support. ISTP bridges the gap between basic IP transport mechanisms and application level signaling. Although not a translation of

the SS7 MTP3 and SCCP protocols, ISTP implements analogues to some of the MTP3 and SCCP functions in a fashion appropriate to distributed systems communicating over an IP network. These capabilities allow the IP network to interact with and receive all the services of the PSTN. As service capabilities evolve over time, these same signaling capabilities may be used to support PSTN access to the PacketCable network's own routing and service databases.

4.2 Media Streams

The IETF standard RTP (RFC 1899 - Real-Time Transport Protocol) is used to transport all media streams in the PacketCable network[32]. PacketCable utilizes the RTP profile for audio and video streams as defined in RFC 1990[35].

The primary media flow paths in the PacketCable network architecture are shown in Figure 6 and are further described below.

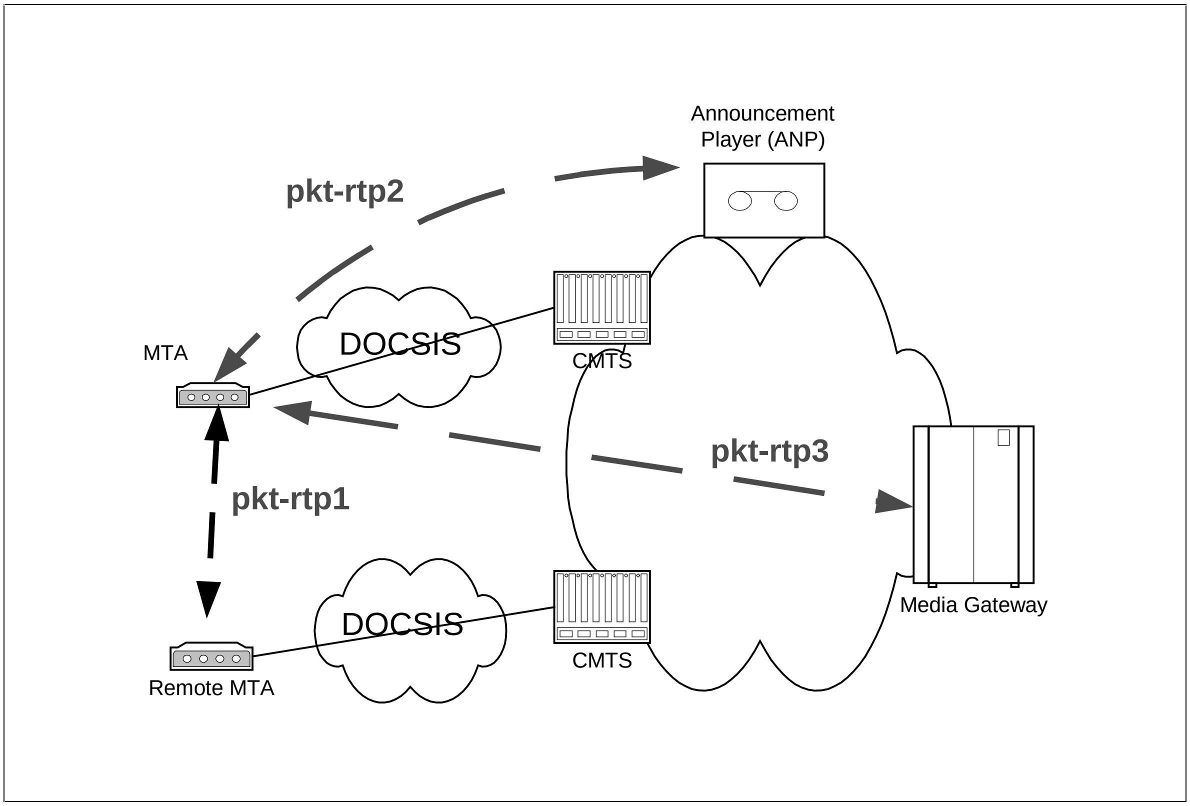


Figure 6. RTP Media Stream Flows in a PacketCable Network

pkt-rtp1: Media flow between MTAs. Includes, for example, encoded voice, video, and fax.

pkt-rtp2: Media flow between the ANP and the MTA. Includes, for example, tones and announcements sent to the MTA by the Announcement Player.

pkt-rtp3: Media flow between the MG and the MTA. Includes, for example, tones, announcements, and PSTN media flow sent to the MTA from the Media Gateway.

RTP encodes a single channel of multimedia information in a single direction. The standard calls for an 8-byte header with each packet. An 8-bit RTP "Payload Type" is defined to indicated which encoding algorithm is used. Most of the standard audio and video algorithms are assigned to particular PT values in the range 0 through 95. The range 96 through 127 is reserved for "dynamic" RTP payload types. The range 128 through 255 is reserved for private administration.

The packet format for RTP data transmitted over IP over Ethernet is depicted in Figure 7 below.

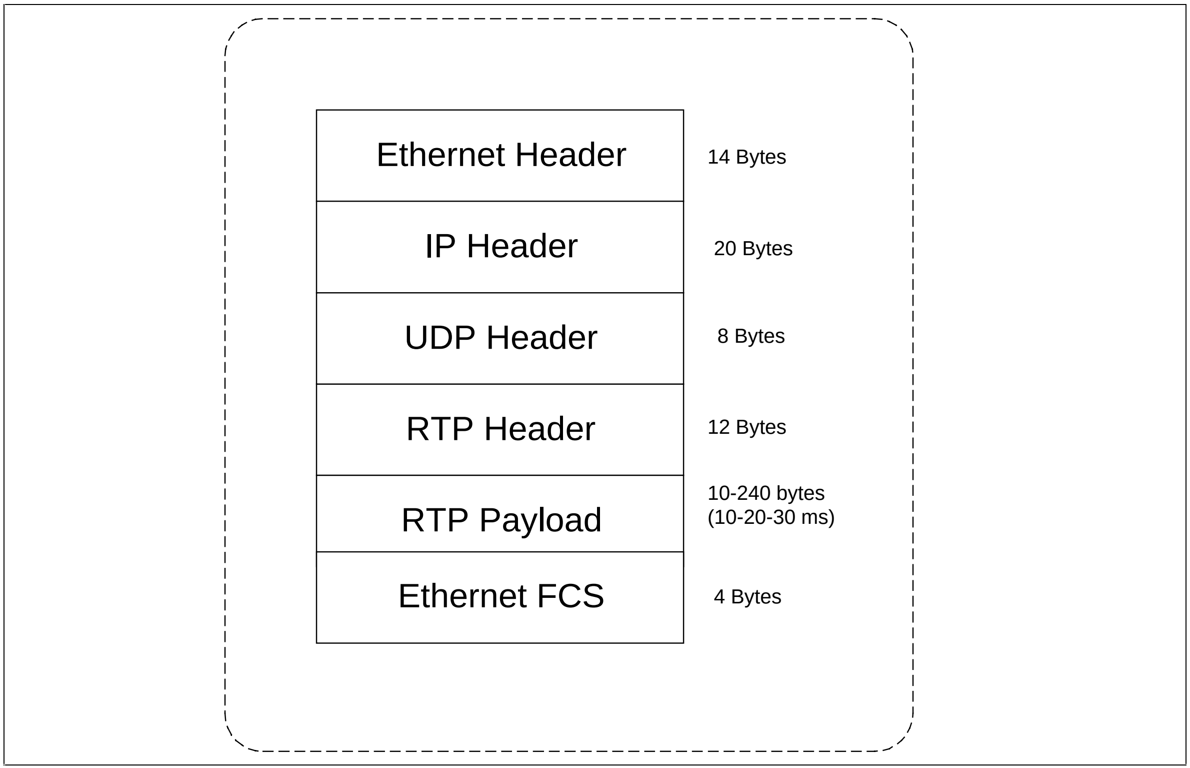


Figure 7. RTP Packet Format

The length of the RTP Payload as well as the frequency with which packets are transmitted depends on the algorithm as defined by the Payload Type field.

RTP sessions are established dynamically by the endpoints involved, so there is no "well-known" UDP port number. The Session Description Protocol (SDP) was developed by the IETF to communicate the particular IP address and UDP port an RTP session is using.

The packet header overhead of Ethernet, IP, UDP, and RTP is significant when compared to a typical RTP Payload size, which can be as small as 10 bytes for packetized voice. The DOCSIS 1.1 specification addresses this issue with a Payload Header Suppression feature for abbreviating common headers.

4.3 MTA Device Provisioning

The scope of MTA Device Provisioning is to enable a MTA to register and provide subscriber services over the HFC network. Provisioning covers initialization, authentication, and registration functions required for MTA device provisioning. The Provisioning Specification [12] also includes attribute definitions required in the MTA configuration file.

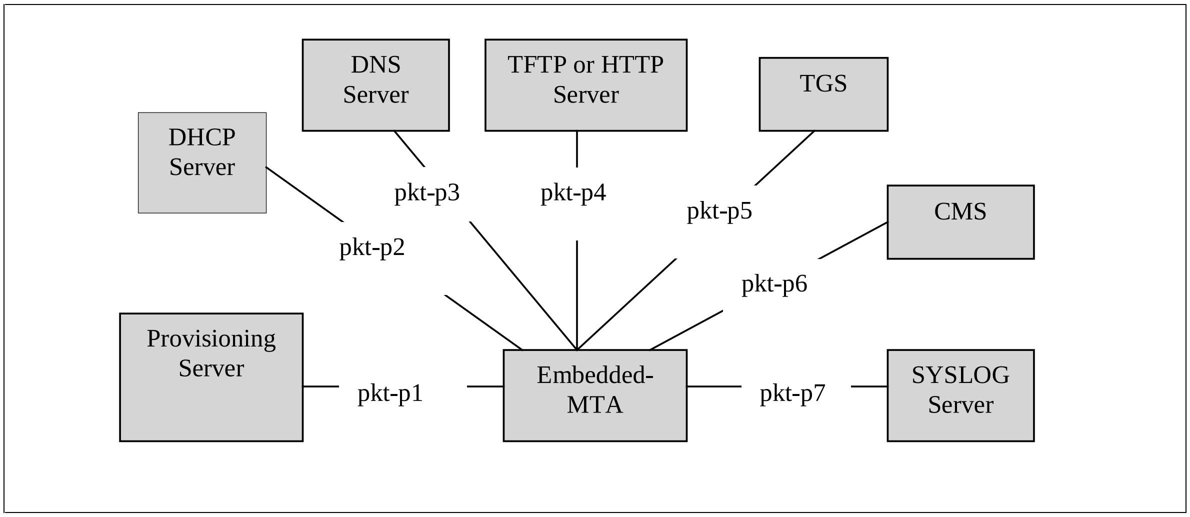


Figure 8. PacketCable Provisioning Interfaces

Table 3 describes the provisioning interfaces shown in the above diagram.

Table 3. Device Provisioning Interfaces

Interface	PacketCable Functional Components	Description
Pkt-p1	MTA-PROV Server	Interface to exchange device capability as well as MTA device and endpoint information between the MTA and Provisioning Server using the SNMP protocol. The MTA also sends notification that provisioning has completed along with a pass/fail status using the SNMP protocol.
Pkt-p2	MTA- DHCP Server	DHCP interface between the MTA and DHCP Server used to assign an IP address to the MTA. If a DNS server is required during provisioning, then the address of this server is also included.
Pkt-p3	MTA – DNS Server	DNS interface between the MTA and DNS Server used to obtain the IP address of a PacketCable server given its fully qualified domain name.
Pkt-p4	MTA – HTTP or TFTP Server	MTA configuration file is downloaded to the MTA from the TFTP Server or HTTP Server.
Pkt-p5	MTA – TGS	MTA obtains a Kerberos ticket from the Ticket Granting Server using the Kerberos protocol.
Pkt-p6	MTA – CMS	MTA establishes an IPSec Security Association with the CMS using the Kerberos protocol.
Pkt-p7	MTA – SYSLOG	MTA sends notification that provisioning has completed along with a pass/fail status to the SYSLOG server via UDP.

4.4 SNMP Element Management Layer Interfaces

PacketCable requires SNMPv3 to interface the MTA to element management systems for MTA device provisioning. SNMPv3 ”traps” and “informs” are supported for event handling, as well as “sets” and “gets” for provisioning. PacketCable MIBs are defined in the MTA MIB specification [8] and the NCS MIB specification [9].

The PacketCable NCS MIB contains Network Call Signaling information for provisioning on both a device and a per endpoint basis. The MTA MIB contains data for device provisioning and for supporting provisioned functions such as event logging. More detailed information on the MIBs framework can be found in the PacketCable MIBs framework specification [10].

4.5 Event Messages Interfaces

4.5.1 Event Message Framework

An Event Message is a data record containing information about network usage and activities. A single Event Message may contain a complete set of data regarding usage or it may only contain part of the total usage information. When correlated by the Record Keeping System (RKS), information contained in multiple Event Messages provides a complete record of the service. This complete record of the service is often referred to as a Call Detail Record (CDR). Event Messages or CDRs may be sent to one or more back office applications such as a billing system, fraud detection system, or pre-paid services processor.

This PacketCable Event Messages specification defines the structure of the Event Message data record and defines RADIUS as the transport protocol. Event Message data record is designed to be flexible and extensible in order to carry information about network usage for a wide variety of services. Additional transport protocols may be recommended in future releases of this specification. Although the scope of the specification is limited to defining Event Messages for basic residential voice capabilities, it is expected that this specification will be expanded to support additional PacketCable-based services. Figure 9 shows a representative Event Message architecture.

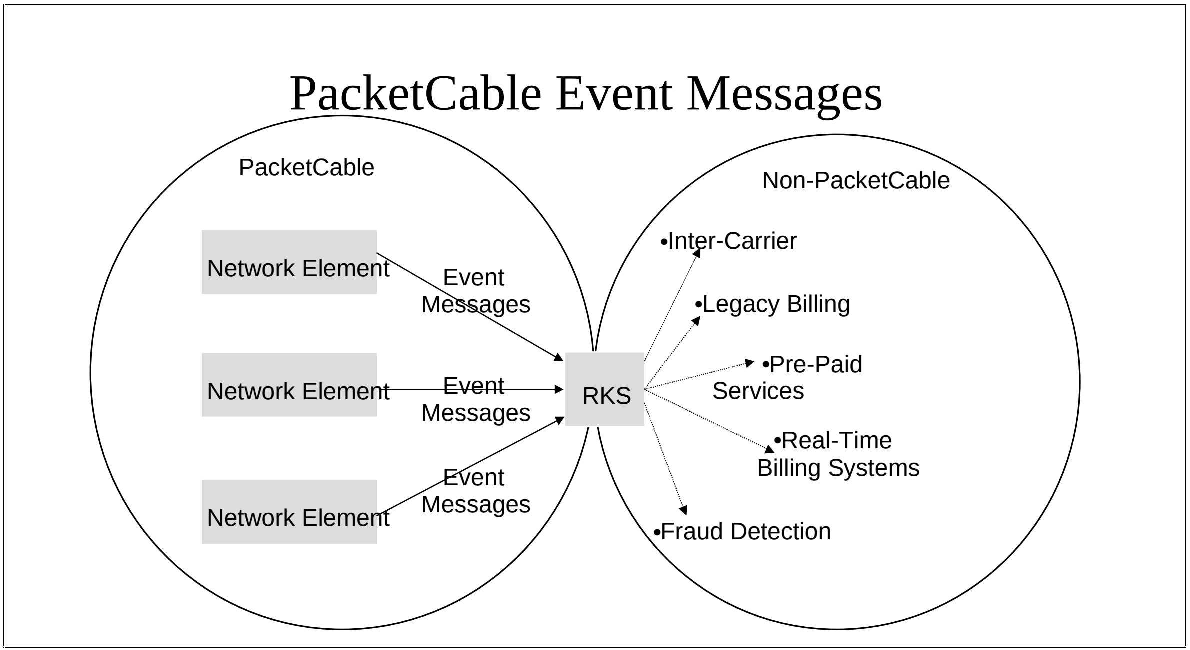


Figure 9. Representative Event Messages Architecture

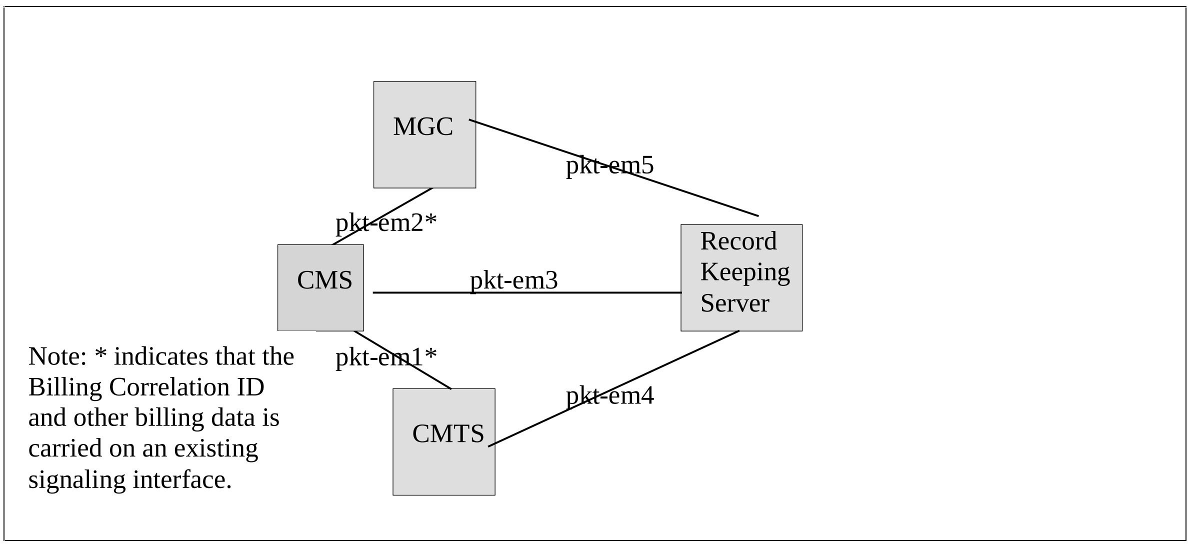


Figure 10. Event Message Interfaces

The following table describes the Event Message interfaces shown in Figure 9.

Table 4. Event Message Interfaces

Interface	PacketCable Functional Component	Description
pkt-em1	CMS-CMTS	DQoS Gate-Set message carrying Billing Correlation ID and other data required for CMTS to send Event Messages to an RKS.
Pkt-em2	CMS-MGC	Vendor-proprietary interface carrying Billing Correlation ID and other data required billing data. Either the CMS or MGC

Interface	PacketCable Functional Component	Description
		may originate a call and therefore need to create the Billing Correlation ID and send this data to the other.
Pkt-em3	CMS-RKS	RADIUS protocol carrying PacketCable Event Messages.
Pkt-em4	CMTS-RKS	RADIUS protocol carrying PacketCable Event Messages.
Pkt-em5	MGC-RKS	RADIUS protocol carrying PacketCable Event Messages.

4.6 Quality-of-Service (QoS)

4.6.1 QoS Framework

Quality of Service signaling interfaces are defined between many of the components of the PacketCable network. Signaling may be handled at the application layer (e.g. SDP parameters), network layer (e.g. RSVP), or the data-link layer (e.g. DOCSIS 1.1 QoS).

From the perspective of the MTA and its access network the PacketCable QoS Framework is represented in Figure 11:

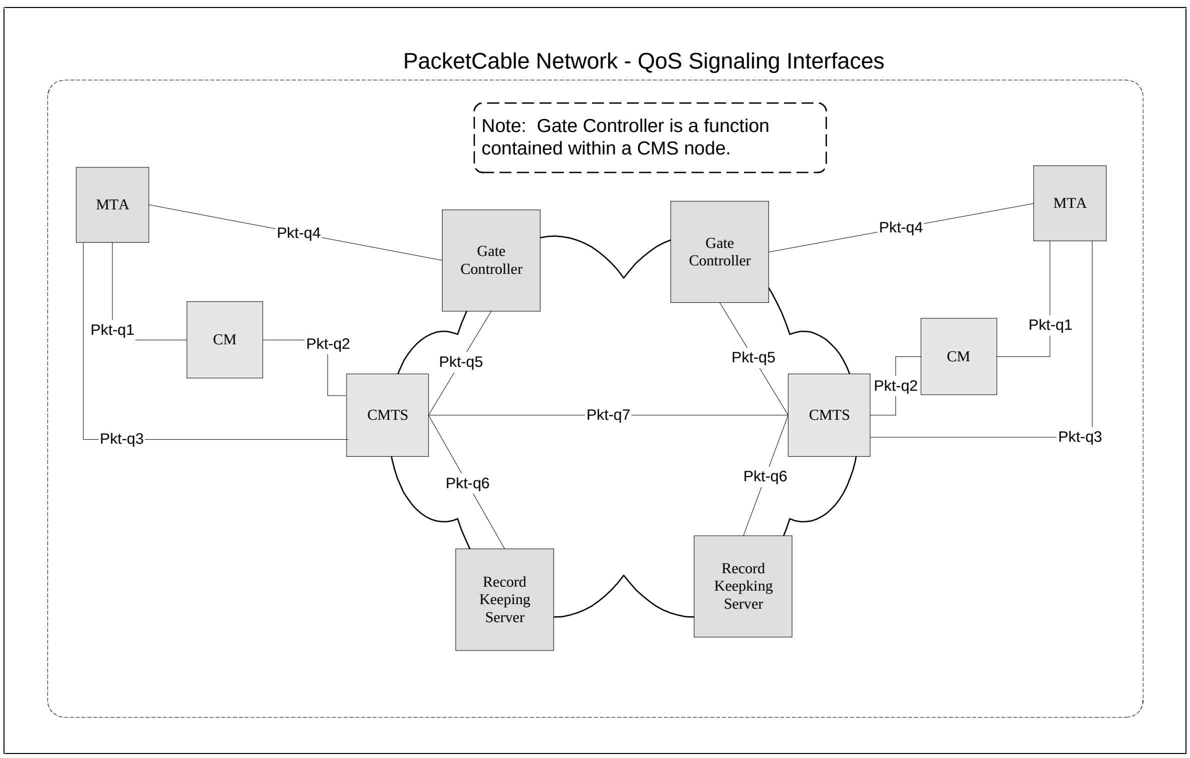


Figure 11. PacketCable QoS Signaling Interfaces

Table 5 briefly identifies each interface and how each interface is used in the Dynamic QoS Specification (DQoS). Two alternatives are shown for this specification: first a general interface that is applicable to either embedded or

standalone MTAs; and second, an optional interface that is available only to embedded MTAs.

Table 5. QoS Interfaces for Standalone and Embedded MTAs

Interface	PacketCable Functional Components	DQoS Embedded/ Standalone MTA	D-QoS Embedded MTA
Pkt-q1	MTA – CM	N/A	E-MTA, MAC Control Service Interface
Pkt-q2	CM – CMTS (DOCSIS)	DOCSIS, CMTS-initiated	DOCSIS, CM-initiated
Pkt-q3	MTA – CMTS	RSVP+[2]	N/A
Pkt-q4	MTA – GC/CMS	NCS/DCS	NCS
Pkt-q5	GC – CMTS	Gate Management	Gate Management
Pkt-q6	CMTS – RKS	Billing	Billing
Pkt-q7	CMTS – CMTS	Gate Management	Gate Management

The function of each QoS interface is further described is defined in Table 6 below.

Table 6. QoS Interfaces

Interface	PacketCable Functional Components	Description
Pkt-q1	MTA – CM	This interface is only defined for the embedded MTA. The interface decomposes into three sub-interfaces: *Control*: used to manage DOCSIS service-flows and their associated QoS traffic parameters and classification rules. *Synchronization*: used to synchronize packet and scheduling for minimization of latency and jitter. *Transport*: used to process packets in the media stream and perform appropriate per-packet QoS processing. The MTA/CM interface is conceptually defined in Appendix E of the DOCSIS RFI specification.
Pkt-q2	CM – CMTS	This is the DOCSIS QoS interface (control, scheduling, and transport). It should be noted that, architecturally, control functions can be initiated from either the CM or the CMTS. However the CMTS is the final policy arbiter and granter of admission into the DOCSIS access network. The following capabilities of the DOCSIS MAC are used within PacketCable: ▪ Multiple service flows, each with its own class of upstream traffic, both single and multiple voice connections per DOCSIS service flow ▪ Prioritized classification of traffic streams to service flows. ▪ Guaranteed minimum/constant bitrate scheduling service ▪ Constant bit rate scheduling with traffic activity detection service

[2] For PacketCable 1.0, only the embedded MTA interfaces as defined in Section 4 of the Dynamic Quality of Service specification are required. The CMTS is not required to support RSVP across the MTA-CMTS interface as defined in DQoS Section 3 [4].

Interface	PacketCable Functional Components	Description
		(slow down, speed up, stop, and restart scheduling) ▪ DOCSIS packet header suppression for increased call density ▪ DOCSIS classification of voice flows to service flow ▪ DOCSIS synchronization of CODEC to CMTS clock and Grant Interval ▪ Two-phase activation of QoS resources ▪ TOS packet marking at network layer ▪ Guarantees on latency and jitter. ▪ Internal sub-layer signaling between PacketCable MTA and DOCSIS (embedded MTA) ▪ This interface is further defined in the DOCSIS RFI specification.
Pkt-q3	MTA – CMTS	The interface is used for request of bandwidth and QoS resources related to the bandwidth. The interface runs on top of layer 4 protocols that bypass the CM. As a result of message exchanges between the MTA and CMTS, service flows are activated using CMTS-originated signaling on interface PKT-Q2. An enhanced version of RSVP is utilized for this signaling.
Pkt-q4	MTA – CMS/GC	Signaling interface between the MTA and CMS/GC. Many parameters are signaled across this interface such as media stream, IP addresses, and Codec selection, but it is possible for certain protocols to either derive QoS semantics from the signaling, or to extend the application layer signaling protocol to contain explicit QoS signaling parameters.
Pkt-q5	CMS/GC – CMTS	This interface is used to manage the dynamic Gates for media stream bearer channels. This interface enables the PacketCable network to request and authorize QoS changes without requiring any layer two DOCSIS access network QoS control functions in MTA. When supporting standalone MTAs no new client-side QoS signaling protocol needs to be designed. The GC/CMS takes responsibility for requesting policy, and the CMTS takes responsibility for access control and quickly setting up QoS on the DOCSIS access link.
Pkt-q6	CMTS – RKS	This interface is used by the CMTS to signal to the RKS all changes in call authorization and usage. This interface is defined in the Event Messages specification.
Pkt-q7	CMTS – CMTS	This interface is used for coordination of resources between the CMTS of the local MTA and the CMTS of the remote MTA. The CMTS is responsible for the allocation and policing of local QoS resources.

4.6.2 Layer Two vs. Layer Four MTA QoS Signaling

QoS signaling from the MTA can be performed either at layer two (DOCSIS) or layer four (RSVP). Layer two signaling is accessible to CM and CMTS devices that exist at the RF boundary of the DOCSIS access network. Layer four signaling is required for devices that are one or more hops removed from the RF boundary of the DOCSIS access network.

If layer two QoS signaling is initiated by the MTA, the MTA must be an embedded MTA. The MTA utilizes the implicit interface for controlling the DOCSIS MAC service flows as suggested by Appendix E of the DOCSIS 1.1 RFI specification.

Layer four QoS signaling is initiated by the MTA; the MTA may be either an embedded MTA or standalone MTA. Enhanced RSVP is used for this signaling and is intercepted by the CMTS. The CMTS utilizes layer two QoS signaling to communicate QoS signaling changes to the CM.

4.6.3 Dynamic Quality-of-Service

PacketCable Dynamic QoS (D-QoS) utilizes the call signaling information at the time that the call is made to dynamically authorize resources for the call. Dynamic QoS prevents various theft of service attack types by integrating the QoS messaging with other protocols and network elements. The network elements that are necessary for a Dynamic QoS control are shown in Figure 11.

The function within the CMTS that performs traffic classification and enforces QoS policy on media streams is called a Gate. The Gate Controller element manages Gates for PacketCable media streams. The following key information is included in signaling between the GC and the CMTS:

- **Maximum Allowed QoS Envelope** – The maximum allowed QoS envelope enumerates the maximum QoS resource (e.g., "2 grants of 160 bytes per 10ms") the MTA is allowed to admit for a given media stream bearer flow. If the MTA requests a value greater than the parameters contained within the envelope the request will be denied.
- **Identity of the media stream endpoints** – The GC/CMS authorizes the parties that are involved in a media stream bearer flow. Using this information the CMTS can police the data stream to ensure that the data stream is destined and originated from the parties that are authorized.
- **Billing Information** – The GC/CMS creates opaque billing information that the CMTS does not have to decode. The information might be as simple as billing identity or the nature of the call. The CMTS forwards this billing information to the RKS as the call is activated or terminated.

The role of each of the PacketCable components in implementing D-QoS is as follows:

Call Management Server/Gate Controller – The CMS/GC is responsible for QoS authorization. The QoS authorization might depend on the type of call, type of user or other parameters defined by policy.

CMTS – Using information supplied by the GC/CMS the CMTS performs admission control on the QoS requests and at the same time polices the data stream to make sure that the data stream is originated and sent to authorized-media stream parties. The CMTS interacts with CM, RKS, MTA, and Terminating CMTS. The responsibilities of CMTS with respect to each of these elements is:

- CMTS to CM – The CMTS is responsible of setting up and tearing down service flows in such a way that the service level agreement it made with the MTA is met. Inasmuch as the CMTS does not trust the CM it polices the traffic from the CM such that the CM works in the way CMTS requested.
- CMTS to Record Keeping Server – The CMTS updates the Record Keeping Server (RKS) each time there is a change in the QoS Service Level Agreement between CMTS and MTA. It uses the Billing Information that is given by GC/CMS to identify each authorized QoS link. The CMTS puts timing information in the message it sends and also buffers the messages if the connection to RKS is severed.
- CMTS to MTA – The MTA makes dynamic requests for modification of QoS traffic parameters. When the CMTS receives the request it makes an authorization check to find out whether the requested characteristics are within the authorized QoS envelope and also whether the media stream endpoints are authorized. Then it provisions the QoS attributes for the RFI link on the CMTS and activates the appropriate QoS traffic parameters via signaling with the CM. When all the provisioning and authorization checks succeed the CMTS sends a success message to the GC/CMS indicating that MTA and CMTS are engaged in a Service Level Agreement.
- CMTS to Terminating CMTS – The CMTS sends messages to the terminating end CMTS (or other terminating access networking device) to ensure that the committed bandwidth on both sides is the same. If the committed bandwidth is not the same then both sides close the connection.

Cable Modem (CM) – Even though the CM is an untrusted entity the CM is responsible for the correct operation of the QoS link between itself and the CMTS. The CMTS makes sure that the CM cannot abuse the RFI link, but it is the responsibility of the CM to utilize the RFI link to provide services that are defined by the DOCSIS 1.1 specification.

Record Keeping Server (RKS) – The RKS acts as a database and stores each event as sent by the CMTS. The RKS stores the messages by attaching received time and network element information. The RKS has to have sufficient interface and/or processing power to allow additional processing to be done.

MTA – The MTA is the entity to which the Service Level Agreement is provided by the access network. The MTA is responsible for the proper use of the QoS link. If it exceeds the traffic authorized by the SLA than it the MTA will not receive the QoS characteristics that it requested. The MTA uses two stage QoS bandwidth allocation – while the call origination is proceeding the QoS resources are admitted, then when the call is answered the resources are activated.

4.7 Announcement Services

Announcements are typically needed for calls that do not complete. Additionally, they may be used to provide enhanced information services to the caller (e.g., calling card, n11 services, etc.). The signaling interfaces to support PacketCable Announcement Services are shown in Figure 12 and are summarized in Table 7 below.

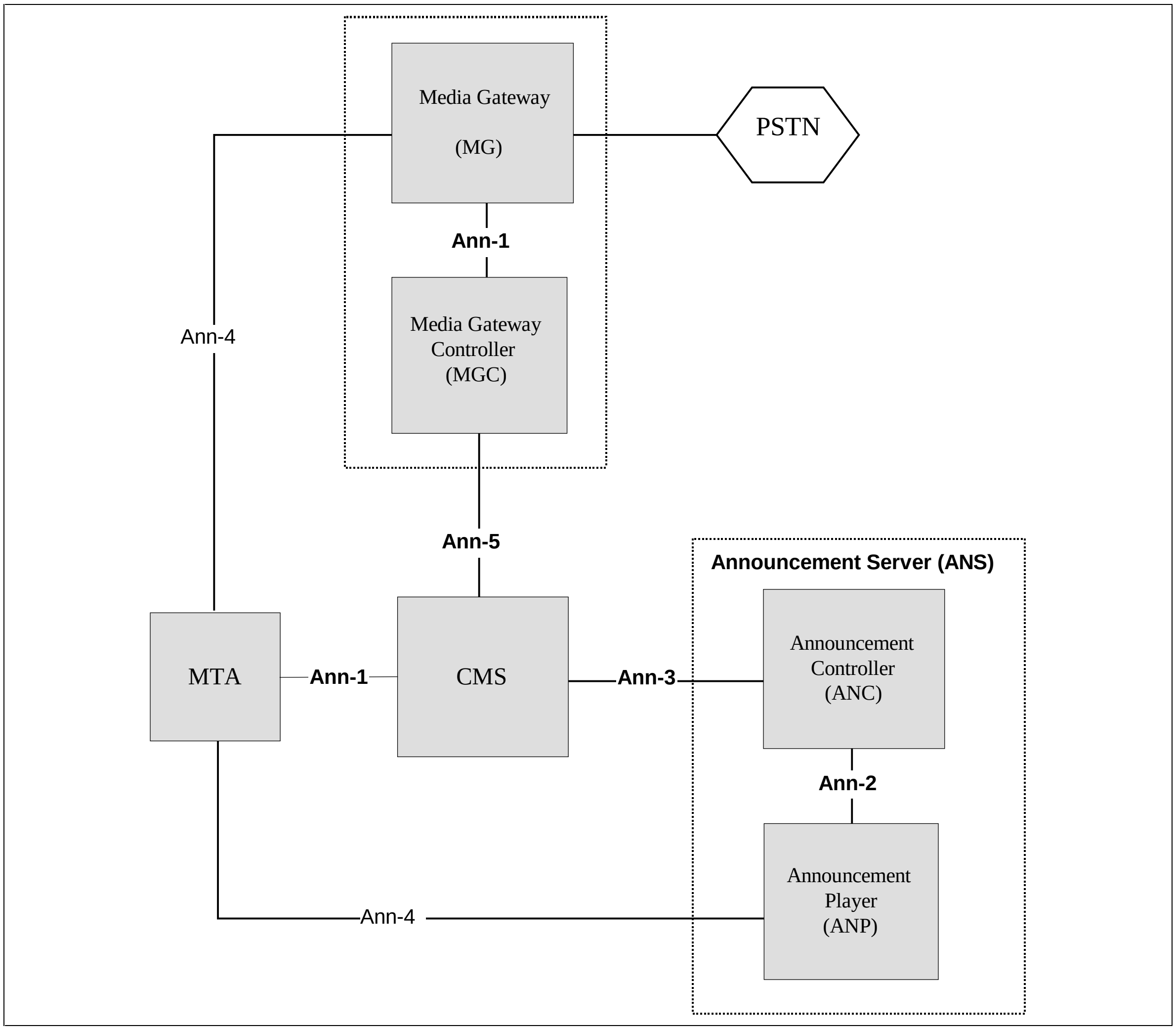


Figure 12. Annoucement Services Components and Interfaces

Table 7. Announcement Interfaces

Interface	PacketCable Functional Components	Protocol
Pkt-ann1	MTA – CMS MGC – MG	The CMS to MTA interface provides a mechanism for the CMS to signal the MTA to play locally stored announcements. Storing announcements in the MTA allows for providing informative progress tones to the end user independently of the network state (e.g., congestion). An NCS-based announcement package has been defined that can be used for both the CMS-MTA and MGC-MG interfaces. Simple, fixed-content announcements (e.g., all-lines-busy) may also be stored at the Media Gateway to provide announcements to PSTN users. The MGC to MG interface provides a mechanism for the MG to play fixed-content announcements to PSTN end-users involved in off-net to on-net calls.
Pkt-ann2	ANC – ANP	The signaling protocol for the ANC to ANP interface is NCS with an announcement package. When the CMS identifies a need for an ANS-based announcement, it sends a request to the ANC over interface Ann-3. Upon receiving a request from the CMS, the ANC opens a session with the Announcement Player using the NCS package.
Pkt-ann3	CMS – ANC	The protocol for the Ann-3 interface is undefined for PacketCable 1.0
Pkt-ann4	ANP-MTA	Defines the media stream format (RTP) for delivery of the announcement from the Announcement Player to the MTA using the RTP protocol.
Pkt-ann5	CMS-MGC	The Ann-5 protocol interface is undefined for PacketCable 1.0.

4.7.1 ANS Physical vs. Logical configuration

The ANC and ANP are logical components that may reside in the same physical entities. When logical components reside in the same physical entity, interfaces between these components become optional. In addition, standalone components using the Ann-2 and Ann-3 interfaces MAY be shared by many network entities.

4.8 Security

4.8.1 Overview

Each of PacketCable’s protocol interfaces is subject to threats that could pose security risks to both the subscriber and service provider. The PacketCable architecture addresses these threats by specifying, for each defined protocol interface, the underlying security mechanisms (such as IPSec) that provide the protocol interface with the security services it requires, e.g., authentication, integrity, confidentiality.

For example, the media stream path may traverse a large number of potentially unknown Internet service and backbone service providers’ wires. As a result, the media stream may be vulnerable to malicious eavesdropping, resulting in a loss of communications privacy. PacketCable core security services include a mechanism for

providing end-to-end encryption of RTP media streams, thus substantially reducing the threat to privacy.

The security services available through PacketCable's core service layer are authentication, access control, integrity, confidentiality and non-repudiation. A PacketCable protocol interface may employ zero, one or more of these services to address its particular security requirements.

PacketCable security addresses the security requirements of each constituent protocol interface by:

- identifying the threat model specific to each constituent protocol interface
- identifying the security services (authentication, authorization, confidentiality, integrity, and non-repudiation) required to address the identified threats.
- specifying the particular security mechanism providing the required security services.

The security mechanisms include both the security protocol (e.g., IPSec, RTP-layer security, and SNMPv3 security) and the supporting key management protocol (e.g., IKE, PKINIT/Kerberos).

Figure 13 provides a summary of all the PacketCable security interfaces.

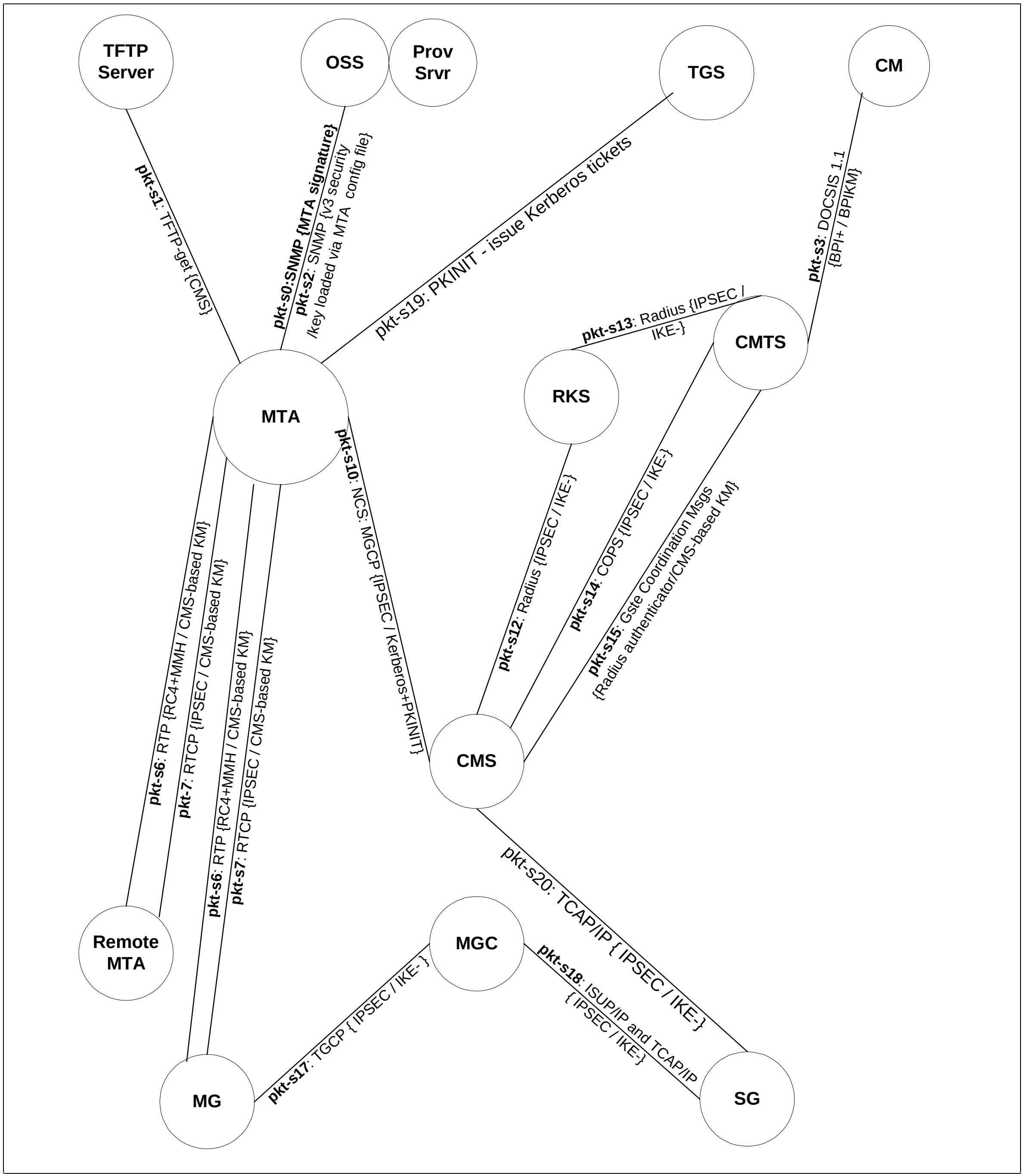


Figure 13. PacketCable Security Interfaces

In Figure 13, each interface is labeled as:

<**label**>: **<protocol> { <security protocol> / <key management protocol> }**

If the key management protocol is missing, it means that it is not needed for that interface. PacketCable interfaces that do not require security are not shown on this diagram.

The following abbreviations are used in the above diagram:

- **IKE-:** IKE with pre-shared keys
- **IKE+:** IKE requires public key certificates
- **CMS-based KM:** Keys randomly generated and distributed by CMS

The following table describes each of the interfaces shown in the above diagram.

Table 8. Security Interfaces

Interface	PacketCable Functional Components	Description
pkt-s0	MTA – Provisioning App	SNMPv3 INFORM from the MTA to the SNMP Manager, followed by optional SNMP GET(s) by the SNMP Manager are used to query MTA device capabilities. This occurs at the time where SNMPv3 keys may not be available, and security is provided with an RSA signature, formatted according to CMS (Cryptographic Message Syntax).
Pkt-s1	MTA – TFTP or HTTP Server	MTA Configuration file download. The MTA downloads a configuration file (with TFTP-get) that is signed by the TFTP server and sealed with the MTA public key, with a CMS (Cryptographic Message Syntax) wrapper. This flow occurs right after an SNMPv3 INFORM followed by an optional SNMP GET(s) – see flow pkt-s0
pkt-s2	MTA – Provisioning App	Standard SNMPv3 security. The SNMPv3 keys are downloaded with the MTA configuration file, using interface pkt-s1.
Pkt-s3	CM – CMTS	BPI+ privacy layer on the HFC link. Both security and key management are defined by DOCSIS 1.1.
pkt-s6	MTA – MTA	End-to-end media packets between two MTAs, or between MTA and MG. RTP packets are encrypted directly with RC4, without any additional security layers. An MMH-based MAC (Message Authentication Code) optionally provides message integrity. Keys are distributed by the CMS to the two endpoints.
Pkt-s7	MTA – MTA	RTCP control protocol for RTP, defined above. Message integrity and encryption provided with IPSEC. Key management is same as for RTP – keys are distributed by CMS.
Pkt-s10	MTA-CMS	MTA-CMS signaling for NCS. Message integrity and privacy via IPSEC. Key management is with Kerberos with PKINIT (public key initial authentication) extension.
Pkt-s12	CMS – RKS	Radius billing events sent by the CMS to the RKS. Radius authentication keys are hardcoded to 0. Instead, IPSEC is used for message integrity as well as privacy. Key management is IKE-.

Interface	PacketCable Functional Components	Description
Pkt-s13	CMTS – RKS	Radius events sent by the CMTS to the RKS. Radius authentication keys are hardcoded to 0. Instead, IPSEC is used for message integrity, as well as privacy. Key management is IKE-.
Pkt-s14	CMS – CMTS	COPS protocol between the GC and the CMTS, used to download QoS authorization to the CMTS. Message integrity and privacy provided with IPSEC. Key management is IKE-.
Pkt-s15	CMS – CMTS	Gate Coordination messages for DQoS. Message integrity is provided with an application-layer (Radius) authenticator. Keys are distributed by local CMS over COPS.
Pkt-s16	N/A	N/A
pkt-s17	MGC – MG	PacketCable interface to the PSTN Media Gateway. IPSEC is used for both message integrity and privacy. Key management is IKE-.
Pkt-s18	MGC – SG	PacketCable interface to the PSTN Signaling Gateway. IPSEC is used for both message integrity and privacy. Key management is IKE-.
Pkt-s19	MTA – TGS	Kerberos/PKINIT key management protocol, where the TGS issues CMS tickets to the MTAs.
Pkt-s20	CMS – SG	CMS queries the PSTN Gateway for LNP (Local Number Portability) and other telephony services. IPSEC is used for both message integrity and privacy. Key management is IKE-.

4.8.2 Device Provisioning Security

The PacketCable security architecture divides device provisioning into three distinct activities: subscriber enrollment, device provisioning and device authorization.

4.8.2.1 Subscriber Enrollment

The subscriber enrollment process establishes a permanent subscriber billing account that uniquely identifies the MTA to the CMS via the MTA's serial number or MAC address. The billing account is also used to identify the services subscribed to by the subscriber for the MTA.

Subscriber enrollment may occur in-band or out-of-band. The actual specification of the subscriber enrollment process is out of scope for PacketCable and may be different for each Service Provider.

4.8.2.2 Device Provisioning

The MTA device verifies the authenticity of the configuration file it downloads from the boot server. Privacy of the configuration data is also provided. The configuration data will be "signed and sealed" by packaging it into a PKCS #7 sealed object.

4.8.2.3 Dynamic Provisioning

SNMPv3 security will be used for dynamically provisioning voice communications capabilities on an embedded-MTA.

4.8.2.4 Device Authorization

Device authorization is when a provisioned MTA Device authenticates itself to the Call Management Server, and establishes a security association with that server prior to becoming fully operational. Device authorization allows subsequent call signaling to be protected under the established security association.

4.8.2.5 Signaling Security

All signaling traffic, which includes QoS signaling, call signaling, and signaling with the PSTN Gateway Interface, will be secured via IPSec. IPSec security association management will be done through the use of two key management protocols: Kerberos/PKINIT and IKE. Kerberos/PKINIT will be used to exchange keys between MTA clients and their CMS server; IKE will be used to manage all other signaling IPSec SAs.

4.8.2.6 Media Stream Security

Each media RTP packet is encrypted for privacy. The MTAs have an ability to negotiate a particular encryption algorithm, although the only one that is currently specified is RC4. Encryption is applied to the packet's payload but not to its header.

Each RTP packet may include an optional message authentication code (MAC). The MAC algorithm can also be negotiated, although the only one that is currently specified is MMH. The MAC computation spans the packet's unencrypted header and encrypted payload.

Keys for the encryption and MAC calculation are derived from the End-End secret, which is exchanged between sending and receiving MTA as part of the call signaling. Thus, the key exchanges for media stream security are secured themselves by the call signaling security.

4.8.2.7 OSS and Billing System Security

The SNMP agents in PacketCable devices implement SNMPv3. The SNMPv3 User Security Model [RFC 2274] provides authentication and privacy services for SNMP traffic. SNMPv3 view-based access control [RFC 2275] may be used for access control to MIB objects.

The IKE key management protocol is used to establish encryption and authentication keys between the Record Keeping Server (RKS) and each PacketCable network element that generates Event Messages. When the network IPSec Security Associations are established, these keys must be created between each RKS (primary, secondary, etc) and every CMS and CMTS. The key exchange between the MGC and RKS may exist and is left to vendor implementation in PacketCable 1.0. The Event

Messages are sent from the CMS and CMTS to the RKS using the RADIUS transport protocol, which is in turn secured by IPSec.

5 NETWORK DESIGN CONSIDERATIONS

5.1 Time Keeping and Reporting Issues

In order to maintain service quality, it is highly recommended that all network equipment clocks be maintained to within 200 milliseconds of Universal Time Coordinated (UTC).

It is recommended that PacketCable networks maintain a timeserver that is accurate to within a specified interval of Universal Time Coordinated (UTC). It is recommended that the server be able to exchange time information with other network equipment such that the receiving equipment is able to be synchronized to the time server clock at the completion of the synchronization protocol exchange.

NTP [38] is the recommended protocol for PacketCable time synchronization.

All systems that generate billing event messages must synchronize their clocks to a network clock source. Synchronization should be done to ensure that the reporting device's own clock remains within ±100 milliseconds of the last synchronization value.

5.2 Timing for Playout Buffer Alignment with Coding Rate

Packet generating and packet handing equipment generally operate with free-running clocks. Problems may arise in the offering of isochronous services due to the plesiochronous nature of these clocks. The difference in clock speed between these plesiochronous entities are generally exhibited as overrun or underrun of the playout buffers.

In order to minimize the occurrence of these conditions, all CMTS' should lock their downstream transmission rate to a clock derived from a source that reflects a Stratum-3 clock. Embedded MTAs should use the downstream transmission rate to derive the clock used to determine packetization period. MTAs should also use this clock to determine the rate of playout from the receive buffer. Non-embedded MTAs should use the average packet arrival interval[3] as the basis for determining their packetization and playout clock.

5.3 IP Addressing

An embedded MTA is a multi-function entity with one function required for CM administration and the second function being the MTA function itself. All IP addresses in a PacketCable network are IPV4.

All PacketCable 1.0 embedded MTAs are required to have 2 IP addresses - one for the CM and one for the MTA. All PacketCable 1.0 embedded MTAs are required to have 2 MAC addresses - one for the CM and one for the MTA.

The following requirements can be met using the dual IP address configuration:

[3] I.e., the interval from arrival of the first bit of packet N to the arrival of the first bit of packet N+1, ignoring intervals where a packet does not arrive within 5 ms of the expected periodicity.

- An embedded MTA containing a dual IP address can assign a private IP address for the CM host function, in the case where NAT translation is not provided elsewhere in the PacketCable network.
- With two IP addresses per MTA, the PacketCable operator can route the voice service packets over a voice backbone and all other packets (data) over a data backbone. Essentially the routing backbone must be configured such that different routing paths are followed for each of the two destination IP addresses.
- The PacketCable operator can simplify network side administration and management functions using separate IP addresses. For example, policy filters can be instantiated that block or permit traffic from the MTA component of the node. In addition, network service providers can provide source address screening services, and network traffic statistics and diagnostics can be collected based upon the IP address of the MTA.

Dual IP addresses result in special considerations that affect the following:

- IP protocol stack implementation of the MTA,
- Implementation of PacketCable OSS and device provisioning protocols,
- Network routing implementations.

5.4 Dynamic IP Addressing Assignment

An operational issue exists regarding the dynamic IP addresses assignment for MTAs. The NCS model specified in PacketCable 1.0 is based on a Call Management Server mapping a subscriber's service to an endpoint identifier and an IP address. Therefore, call processing operations would be affected if the MTA's IP address changed during an active call. However, there are some recommendations that network operators and MTA vendors can employ to eliminate this situation.

1. When configuring DHCP options for an MTA, the network operator should configure the IP Address Lease Time (Option Code 51) to specify a very long lease time. This option is detailed in "Dynamic Host Configuration Protocol" [RFC2131] and "DHCP Options and BOOTP Vendor Extensions" [RFC2132]. Per paragraph 3.3 of RFC2131, a lease time setting of "0xffffffff" represents an infinite lease. Use of long lease times will minimize the possibility that an active MTA would be unable to renew its assigned IP address lease.
2. Network operators should also configure an MTA's DHCP Timer T1 and T2 values (Option Codes 58 and 59, respectively) to be no more than the default values specified in paragraph 4.4.5 of RFC2131. Configuring an MTA to begin it's IP address lease time renewal process at no more than 50% of the assigned lease time, combined with the use of very long lease time values, will further ensure that an MTA will be able to renew its IP address lease.
3. MTA vendors should implement mechanisms to prevent an MTA from entering the RENEWING state (as specified in RFC2131) while call

processing is active. It is left to vendor implementation to determine exactly how this capability might best be implemented in their product.

5.5 FQDN Assignment

The following are potential operational issues that are expected to be resolved through vendor-specific implementations:

It is assumed that the OSS back office will generate the appropriate FQDNs for all PacketCable devices, and pass this data to the appropriate PacketCable devices and other network elements. These interfaces are not defined in PacketCable 1.0.

An operational issue exists regarding synchronization of databases within the provisioning domain. Specifically the DHCP database, and the DNS table's require concurrent updates when a subscriber record changes (this includes creation). RFC2131 provides a mechanism by which a host (a DHCP client) could acquire certain configuration information, specifically its IP address(es). However, DHCP does not provide any mechanisms to update the DNS Resource Records that contain the information about mapping between the host's FQDN and its IP address(es) (i.e., the Address and Pointer Resource Records). Thus the information maintained by DNS for a DHCP client may be incorrect – a host (the client) could acquire its address by using DHCP, but the Address Resource Record for the host's FQDN wouldn't reflect the address that the host acquired, and the Pointer Resource Record for the acquired address wouldn't reflect the host's FQDN.

The problem has two main issues. One, how do you update the DNS system when a new IP address is dispensed, and two, how long do you make time out values for RR's. Both of these issues are vendor implementation issues and therefore lie outside of the scope of PacketCable specifications. However, some recommendations on 'best practices' are outlined in RFC 2131.

5.6 Priority Marking of Signaling and Media Stream Packets

Both the media stream and the signaling stream for PacketCable-based services require methods for properly marking and transporting packets at a sufficiently high level of quality of service, both in the DOCSIS access network and in the managed IP backbone.

The primary mechanism for providing low-latency quality of service for media streams in the access network is the DOCSIS 1.1 flow classification service. This service classifies packets into specific flows based upon packet fields such as IP source and destination addresses and UDP port number parameters. In the upstream such classified packets are transported via an appropriate constant bit rate service (for current codecs) as dynamically scheduled by the CMTS. In the downstream the packets are transported via an appropriate high priority queuing and scheduling mechanism. DQoS (between CMS and CMTS) and DOCSIS (between CMTS and CM) signaling mechanisms are used to dynamically setup the media stream flow classification rules and service flow QoS traffic parameters.

In addition to flow classification, it is useful to mark media stream packets with appropriate priority markings. Such priority markings can be utilized within CMTS/CM queuing systems and also within Diff-serv managed QoS backbones (which may not contain flow classification mechanisms) in order to provide high priority QoS treatment of such packets. It should be noted that while no definition is provided as to how QoS is managed in the Managed IP backbone in the current architecture, it is expected that the mechanisms defined for PacketCable QoS will be usable within such a managed backbone.

Signaling packets may also benefit from prioritized QoS services. In particular as an access network becomes loaded to capacity, it may be important to forward signaling packets at a higher priority than data packets in order to avoid excessive signaling latency. It should be noted that from a network traffic-engineering point of view it has not yet been determined whether high priority treatment of signaling packets is required. If signaling prioritization is desired, then the method for providing prioritized QoS is based upon two mechanisms. First mark all signaling packets with a high priority marking, and second provide a DOCSIS Classifier that classifies such packets to be transported on a higher priority service flow. The Classifier can be as simple as mapping all upstream packets with this priority to the high priority SID, or can be more complex and also identify the IP address of the MTA(s) which originate the signaling. The higher priority service flow may be either statically provisioned or dynamically created by the administrator of the CMTS. It should be noted that if the administrator is concerned about theft of service of the high priority service flow, then he may configure the service flow for high priority (low latency) but low bandwidth.

Marking of packets for both the media stream and the signaling stream (NCS) is performed by the MTA and the CMS. The marking is performed at the IP layer using a field that has alternately been called the TOS byte or the Diff-serv Code Point (DSCP). The TOS byte was the original definition of the byte while DSCP is the new definition of the byte as used by the IETF Diff-serv architecture. Because two formats for this byte exist, the configuration of the values should be done in a format and type independent way (in the MIBs for the MTA and Call Agent).

Management Information Bases (MIBS) are defined in PacketCable for assigning the provisioned and default values for media stream priority marking and signaling stream priority marking (e.g. a value of ‘3’ for signaling and a value of ‘5’ for media). It should be noted that in NCS the signaled SDP parameters may contain overrides for the configured media stream priority marking value on a connection by connection basis. No mechanism currently exists for dynamically overriding the provisioned priority marking value of the signaling stream on a call by call basis.

5.7 Fax Support

PacketCable supports real-time fax transmission. Fax is ‘best’ accomplished using the G.711 standard for audio encoding/decoding. If a call is established using a compressed codec, the embedded MTA will have to be instructed to look for fax tones. If fax tones are detected, the CMS will have to be notified and the MTA will be

instructed to switch to using G.711. Note that this places a requirement on the embedded device to monitor the media stream and detect fax tones.

Support for switching over to fax from a voice call is required; however, switching back to voice from fax is not required (*i.e.*, monitoring the fax media stream for an ending signal and then switching back to a low bandwidth codec).

Local termination of fax and translating the fax stream to an IP fax relay data stream is not required in this version of the architecture.

5.8 Analog Modem Support

Analog modems are supported in a similar fashion to fax—a MTA will be asked to detect modem tones and, when such tones are detected, the CMS will instruct the MTA to switch over to the G.711 codec if it is not already in use. Note that this places a requirement on the embedded device to monitor the voice stream and to detect analog modem tones.

Switching over to G.711 to support analog modem signaling from a voice call will be supported; however, switching back to voice from modem signaling will not be required to be supported (*i.e.*, monitoring the modem media stream for an ending signal and then switching back to a low-bandwidth codec).

Local termination of modems and translating the modem stream to an IP modem relay data stream is not required in this version of the architecture.

6 FUTURE CONSIDERATIONS

The goal of PacketCable is to enable full-featured, robust, wide-scale deployment for global cable IP networks. To meet this goal, the PacketCable project will continue to evolve to support ground-breaking services, features, and functionality. The project evolution is accompanied by an architecture evolution as new features are added and old ones are re-designed. Continuing the design evolution allows cutting-edge techniques to be added to optimize access, maximize bandwidth utilization and provide for advanced multimedia features.

Future PacketCable network capabilities will likely include but are not limited to, inter-zone and inter-domain signaling, tools for client power management, primary line support, fault management and performance management**.** Additional equipment types such as standalone MTAs (S-MTAs) and new media servers are also planned for specification.

Potential changes in other areas could address enhanced QoS, provisioning and security capabilities. For example, QoS could add layer four QoS signaling (for providing service to standalone MTAs via RSVP with enhancements) and a specific protocol for backbone networks. Provisioning for subscriber installed and dynamically provisioned MTAs (out-of-box registration and activation of service) may be possible in the near future on PacketCable networks. Security could include support for new network devices, and interfaces to those devices. Additionally, security would be added for the MTA-CMTS interface (RSVP) for QoS signaling, and for any newly defined provisioning and signaling protocols. Also, an increased choice in the number of cryptographic algorithms may be made available.

Appendix A. Acknowledgements

Many contributors are to be acknowledged for the development of the PacketCable architecture framework specification. Certainly all of the participants in the various technical task forces have made a contribution through their contribution to the working groups. In particular, the following individuals are recognized by their contributions and review of this specification – Flemming Andreasen (Telcordia), Burcak Beser (3COM), Chet Birger (YAS Corp.), David Bukovinsky (CableLabs), John Chapman (Cisco), Frank Christofferson (CableLabs), Nancy Davoust (CableLabs), Raj Deshpande (Motorola), Jonathan Fellows (General Instrument), Bill Foster (Cisco), Keith Kelly (Netspeak), William Marshall (AT&T), Sasha Medvinsky (General Instrument), Ed Miller (CableLabs), Rick Morris (Arris Interactive), John Pickens (Com21), Michael Patrick (Motorola), Stephane Proulx (Broadsoft), K. K. Ramakrishnan (AT&T), Glenn Russell (CableLabs), Maria Stachelek (CableLabs), Don Stanwyck (IPUnity), Andrew Sundelin (CableLabs), and Venkatesh Sunkad (CableLabs).

Appendix B. References

[1] "PacketCable Product Specification," Cable Television Laboratories, Inc. /MCNS, November 25, 1998.

[2] "PacketCable Specification Overview – Version 1.0," Cable Television Laboratories, Inc. /MCNS, July 29, 1998.

[3] "PacketCable Audio/Video Codecs Specification,"PKT-SP-CODEC-I01-991201, December 01, 1999, Cable Television Laboratories, Inc., available at www.PacketCable.com.

[4] "PacketCable Dynamic Quality-of-Service Specification,"PKT-SP-DQOS-I01-991201, December 01, 1999, Cable Television Laboratories, Inc., available at www.PacketCable.com.

[5] "PacketCable Network-Based Call Signaling Protocol specification," PKT-SP-EC-MGCP-I02-991201, December 01, 1999, Cable Television Laboratories, Inc., available at www.PacketCable.com.

[6] "PacketCable Event Messages Specification," PKT-SP-EM-I01-991201, December 01, Cable Television Laboratories, Inc., available at www.PacketCable.com.

[7] "PacketCable Internet Signaling Transport Protocol (ISTP) Specification,"PKT-SP-ISTP-I01-991201, December 01, 1999, Cable Television Laboratories, Inc., available at www.PacketCable.com.

[8] "PacketCable MTA MIB Specification,"PKT-SP-MIB-MTA-I01-991201, December 01, 1999, Cable Television Laboratories, Inc., available at www.PacketCable.com.

[9] "PacketCable NCS MIB Specification," PKT-SP-MIB-NCS-I01-991201, December 01, 1999, Cable Television Laboratories, Inc., available at www.PacketCable.com.

[10] "PacketCable MIBs Framework Specification,"PKT-SP-MIBS-I01-991201, December 01, 1999, Cable Television Laboratories, Inc., available at www.PacketCable.com.

[11] "PacketCable PSTN Gateway Call Signaling Protocol Specification,"PKT-SP-TGCP-I01-991201, December 01, 1999, Cable Television Laboratories, Inc., available at www.PacketCable.com.

[12] "PacketCable MTA Device Provisioning Specification,"PKT-SP-PROV-I01-991201, December 01, 1999, Cable Television Laboratories, Inc., available at www.PacketCable.com.

[13] "PacketCable Security Specification,"PKT-SP-SEC-I01-991201, December 01, 1999, Cable Television Laboratories, Inc., available at www.PacketCable.com.

[14] "PacketCable Call Flows," PKT-TR-CF-991201, CableLabs, December 01, 1999, Cable Television Laboratories, Inc., available at www.PacketCable.com.

[15] "PacketCable OSS Overview," PKT-TR-OSSI-V01-990730, July 30, 1999, Cable Television Laboratories, Inc., available at www.PacketCable.com.

[16] "PacketCable Functional Requirements PSTN Gateway Architecture Description and Functional Requirements," PKT-FR-PSTNGWARCH-990305, March 5, 1999, Cable Television Laboratories, Inc.

[17] "PacketCable Event Messaging White Paper," PKT-OSS-TD01-990329

[18] "Distributed Open System Architecture," ATT.

[19] "Data-Over-Cable Service Interface Specifications, Radio Frequency Interface Specification," SP-RFIv1.1-I03-991105. Cable Television Laboratories, Inc. Available at www.cablemodem.com.

[20] "DOCSIS QoS Management Information Base," draft-ietf-ipcdn-qos-mib-00.txt. Cable Television Laboratories, Inc. Available at www.cablemodem.com.

[21] "Data-Over-Cable Service Interface Specifications," Cable Modem Termination System – Network Side Interface Specification," SP-CMTS-NSII01- 960702. Cable Television Laboratories, Inc. Available at www.cablemodem.com.

[22] "Data-Over-Cable Service Interface Specifications, Cable Modem to Subscriber Premise Equipment Interface Specification," SP-CMCI-I03-991115. Cable Television Laboratories, Inc. Available at www.cablemodem.com.

[23] "Data-Over-Cable Service Interface Specifications, Operations Support System Interface Specification," SP-OSSI-I02-990113. Cable Television Laboratories, Inc. Available at www.cablemodem.com.

[24] "Data-Over-Cable Service Interface Specifications, Cable Modem Telephony Return Interface Specification," SP-CMTRI-I01-970804. Cable Television Laboratories, Inc. Available at www.cablemodem.com.

[25] "Data-Over-Cable Service Interface Specifications, Baseline Privacy Plus Interface Specification," SP-BPI+-I03-991105. Cable Television Laboratories, Inc. Available at www.cablemodem.com.

[26] "COPS Usage for RSVP," IETF (Boyle, et. al.), Internet Draft, draft-ietf-rap-cops-rsvp-05.txt, June 1999 (expires December 1999).

[27] "An Architecture for Differentiated Services," IETF RFC 2475.

[28] "Definition of the Differentiated Services Field (DS Field) in the Ipv4 and Ipv6 Headers," IETF RFC 2474.

[29] "The COPS (Common Open Policy Service) Protocol," IETF (J. Boyle, R. Cohen, D. Durham, S. Herzog, R. Rajan, A. Sastry), Internet Draft, draft-ietf-rap-cops-08.txt, Nov. 6, 1999 (expires April 2000).

[30] "Resource reSerVation Protocol – Version 1 Functional Specification," IETF RFC 2205.

[31] "CANOE – Cable Access Network Operations Extensions for DOCSIS PacketCable Networks," 3Com, August 17, 1998.

[32] "RTP: A Transport Protocol for Real-Time Application," IETF RFC 1889.

[33] "SDP: Session Description Protocol," IETF RFC 2327.

[34] "Dynamic Host Configuration Protocol", IETF RFC 2131.

[35] "RTP Profile for Audio and Video Conferences with Minimal Control," IETF RFC 1890.

[36] "Compressing IP/UDP/RTP Headers for Low-Speed Serial Links," draft-ietf-avt-crtp-05.txt

[37] "The Kerberos Network Authentication Service (V5)", IETF Draft (Clifford Neuman, John Kohl, Theodore Ts'o), draft-ietf-cat-kerberos-revisions-04.txt, July, 1999.

[38] "Network Time Protocol" IETF RFC 1119.

Appendix C. Glossary

AAA	Authentication, Authorization and Accounting
Access Control	Limiting the flow of information from the resources of a system only to authorized persons, programs, processes or other system resources on a network.
Active	A service flow is said to be "active" when it is permitted to forward data packets. A service flow must first be admitted before it is active.
Admitted	A service flow is said to be "admitted" when the CMTS has reserved resources (e.g. bandwidth) for it on the DOCSIS network.
AF	Assured Forwarding. A Diffserv Per Hop Behavior.
AH	Authentication header is an IPSec security protocol that provides message integrity for complete IP packets, including the IP header.
A-link	A-Links are SS7 links that interconnect STPs and either SSPs or SCPs. 'A' stands for "Access".
Announcement Server	An announcement server plays informational announcements in PacketCable network. Announcements are needed for communications that do not complete and to provide enhanced information services to the user.
AMA	Automated Message Accounting., a standard form of call detail records (CDRs) developed and administered by Bellcore (now Telcordia Technologies)
Asymmetric Key	An encryption key or a decryption key used in a public key cryptography, where encryption and decryption keys are always distinct.
AT	Access Tandem. A switching point in PSTN networks that allows access to an entire calling area.
ATM	Asynchronous Transfer Mode. A protocol for the transmission of a variety of digital signals using uniform 53-byte cells.
Authentication	The process of verifying the claimed identity of an entity to another entity.
Authenticity	The ability to ensure that the given information is without modification or forgery and was in fact produced by the entity who claims to have given the information.
Authorization	The act of giving access to a service or device if one has the permission to have the access.
BAF	Bellcore AMA Format, another way of saying AMA
BPI+	Baseline Privacy Interface Plus is the security portion of the DOCSIS 1.1 standard which runs on the MAC layer.
CBC	Cipher block chaining mode is an option in block ciphers that combine (XOR) the previous block of ciphertext with the current block of plaintext before encrypting that block of the message.
CBR	Constant Bit Rate.
CA	Certification Authority - a trusted organization that accepts certificate applications from entities, authenticates applications, issues certificates and maintains status information about certificates.
CA	Call Agent. In this specification "Call Agent" is part of the CMS that maintains call state, and controls the line side of calls.
CDR	Call Detail Record. A single CDR is generated at the end of each billable activity. A single billable activity may also generate multiple CDRs

CIC	Circuit Identification Code. In ANSI SS7, a two octet number that uniquely identifies a DSO circuit within the scope of a single SS7 Point Code.
CID	Circuit ID (Pronounced "Kid"). This uniquely identifies an ISUP DS0 circuit on a Media Gateway. It is a combination of the circuit's SS7 gateway point code and Circuit Identification Code (CIC). The SS7 DPC is associated with the Signaling Gateway that has domain over the circuit in question.
CIF	Common Intermediate Format. A coding format for digital signals.
Cipher	An algorithm that transforms data between plaintext and ciphertext.
Ciphersuite	A set which must contain both an encryption algorithm and a message authentication algorithm (e.g. a MAC or an HMAC). In general, it may also contain a key management algorithm, which does not apply in the context of PacketCable.
Ciphertext	The (encrypted) message output from a cryptographic algorithm that is in a format that is unintelligible.
CIR	Committed Information Rate.
Cleartext	The original (unencrypted) state of a message or data.
CM	DOCSIS Cable Modem.
CMS	Cryptographic Message Syntax
CMS	Call Management Server. Controls the audio call connections. Also called a Call Agent in MGCP/SGCP terminology.
CMTS	Cable Modem Termination System, the device at a cable head-end which implements the DOCSIS RFI MAC protocol and connects to CMs over an HFC network.
Codec	COder-DECoder
Confidentiality	A way to ensure that information is not disclosed to any one other then the intended parties. Information is encrypted to provide confidentiality. Also known as privacy.
COPS	Common Open Policy Service Protocol is currently an internet draft which describes a client/server model for supporting policy control over QoS Signaling Protocols and provisioned QoS resource management.
CoS	Class of Service. The type 4 tuple of a DOCSIS 1.0 configuration file.
CSR	Customer Service Representative
Cryptoanalysis	The process of recovering the plaintext of a message or the encryption key without access to the key.
Cryptographic algorithm	An algorithm used to transfer text between plaintext and ciphertext.
DA	Directory Assistance
DE	Default. A Diffserv Per Hop Behavior.
Decipherment	A procedure applied to ciphertext to translate it into plaintext.
Decryption	A procedure applied to ciphertext to translate it into plaintext.
Decryption key	The key in the cryptographic algorithm to translate the ciphertext to plaintext
DHCP	Dynamic Host Configuration Protocol.
DHCP-D	DHCP Default - Network Provider DHCP Server
Digital certificate	A binding between an entity's public key and one or more attributes relating to its identity, also known as a public key certificate

Digital signature	A data value generated by a public key algorithm based on the contents of a block of data and a private key, yielding an individualized cryptographic checksum
DNS	Domain Name Server
Downstream	The direction from the head-end toward the subscriber location.
DSCP	Diffserv Code Point. A field in every IP packet which identifies the Diffserv Per Hop Behavior. In IP version 4, the TOS byte is redefined to be the DSCP. In IP version 6, the Traffic Class octet is used as the DSCP. See Appendix A.
DOCSIS	Data Over Cable System Interface Specification.
DPC	Destination Point Code. In ANSI SS7, a 3 octet number which uniquely identifies an SS7 Signaling Point, either an SSP, STP, or SCP.
DQoS	Dynamic Quality of Service, i.e. assigned on the fly for each call depending on the QoS requested
DTMF	Dual-tone Multi Frequency (tones)
EF	Expedited Forwarding. A Diffserv Per Hop Behavior.
E-MTA	Embedded MTA – a single node which contains both an MTA and a cable modem.
Encipherment	A method used to translate information in plaintext into ciphertext.
Encryption	A method used to translate information in plaintext into ciphertext.
Encryption Key	The key used in a cryptographic algorithm to translate the plaintext to ciphertext.
Endpoint	A Terminal, Gateway or MCU
EO	End Office. A switching point in the PSTN Local Exchange Carrier network that directly connects to subscriber access lines.
Errored Second	Any 1-sec interval containing at least one bit error.
ESP	IPSec Encapsulation Security Payload protocol that provides both IP packet encryption and optional message integrity, not covering the IP packet header.
ETSI	European Telecommunications Standards Institute
Event Message	Message capturing a single portion of a call connection
FGD	Feature Group D signaling. A type of circuit used for exchanging traffic with a PSTN LEC network.
F-link	F-Links are SS7 links that directly connect two SS7 end points, such as two SSPs. 'F' stands for "Fully Associated"
Flow [IP Flow]	A unidirectional sequence of packets identified by ISO Layer 3 and Layer 4 header information. This information includes source/destination IP addresses, source/destination port numbers, protocol ID. Multiple multimedia streams may be carried in a single IP Flow.
Flow [DOCSIS Flow]	(a.k.a. DOCSIS-QoS "service flow"). A unidirectional sequence of packets associated with a SID and a QoS. Multiple multimedia streams may be carried in a single DOCSIS Flow.
FQDN	Fully Qualified Domain Name. Refer to IETF RFC 821 for details.
Gateway	Devices bridging between the PacketCable IP Telephony world and the PSTN. Examples are the Media Gateway which provides the bearer circuit interfaces to the PSTN and transcodes the media stream, and the Signaling Gateway which sends and receives circuit switched network signaling tot he edge of the PacketCable network.

H.323	An ISO standard for transmitting and controlling audio and video information. The H.323 standard calls for the use of the H.225/H.245 protocol for call control between a "gateway" audio/video endpoint and a "gatekeeper" function.
Header	Protocol control information located at the beginning of a protocol data unit.
HFC	Hybrid Fiber/Coax(ial [cable]), HFC system is a broadband bi-directional shared media transmission system using fiber trunks between the head-end and the fiber nodes, and coaxial distribution from the fiber nodes to the customer locations.
H.GCP	A protocol for media gateway control being developed by ITU.
HMAC	Hashed Message Authentication Code – a message authentication algorithm, based on either SHA-1 or MD5 hash and defined in RFC 2104.
HTTP	Hyper Text Transfer Protocol. Refer to IETF RFC 1945 and RFC 2068.
IANA	Internet Assigned Numbered Authority. See www.ietf.org for details.
IC or IXC	Inter-exchange Carrier. A long distance carrier.
IETF	Internet Engineering Task Force. A body responsible, among other things, for developing standards used in the Internet.
IKE	Internet Key Exchange is a key management mechanism used to negotiate and derive keys for SAs in IPSec.
IKE–	A notation defined to refer to the use of IKE with pre-shared keys for authentication.
IKE+	A notation defined to refer to the use of IKE, which requires digital certificates for authentication.
Integrity	A way to ensure that information is not modified except by those who are authorized to do so.
IntraLATA	Within a Local Access Transport Area
IP	Internet Protocol. An Internet network-layer protocol.
IPSec	Internet Protocol Security, a collection of Internet standards for protecting IP packets with encryption and authentication.
ISDN	Integrated Services Digital Network
ISUP	ISDN User Part is a protocol within the SS7 suite of protocols that is used for call signaling within an SS7 network.
ISTP	Internet Signaling Transport Protocol
ISTP – User	Any element, node, or software process that uses the ISTP stack for signaling communications.
ITU	International Telecommunication Union
IVR	Interactive Voice Response System
Jitter	Variability in the delay of a stream of incoming packets making up a flow such as a voice call
Kerberos	A secret-key network authentication protocol that uses a choice of cryptographic algorithms for encryption and a centralized key database for authentication.
Key	A mathematical value input into the selected cryptographic algorithm.
Key Exchange	The swapping of public keys between entities to be used to encrypt communication between the entities.

Key Management	The process of distributing shared symmetric keys needed to run a security protocol.
Keying Material	A set of cryptographic keys and their associated parameters, normally associated with a particular run of a security protocol.
Key Pair	An associated public and private key where the correspondence between the two are mathematically related, but it is computationally infeasible to derive the private key from the public key.
Keyspace	The range of all possible values of the key for a particular cryptographic algorithm.
LATA	Local Access and Transport Area
Latency	The time, expressed in quantity of symbols, taken for a signal element to pass through a device.
LD	Long Distance
LIDB	Line Information Data Base, containing information on telephone customers required for real-time access such as calling card personal identification numbers (PINs) for real-time validation
Link Encryption	Cryptography applied to data as it travels on data links between the network devices.
LLC	Logical Link Control, used here to mean the Ethernet Packet header and optional 802.1P tag which may encapsulate an IP packet. A sublayer of the Data Link Layer.
LNP	Local Number Portability. Allows a customer to retain the same phone number when switching from one local service provider to another.
LSSGR	LATA Switching Systems Generic Requirements
MAC	Message Authentication Code - a fixed length data item that is sent together with a message to ensure integrity, also known as a MIC.
MAC	Media Access Control. It is a sublayer of the Data Link Layer. It normally runs directly over the physical layer.
MC	Multipoint Controller
MD5	Message Digest 5 - a one-way hash algorithm which maps variable length plaintext into fixed length (16 byte) ciphertext.
MDCP	A media gateway control specification submitted to IETF by Lucent. Now called SCTP.
MDU	Multi-Dwelling Unit. Multiple units within the same physical building. The term is usually associated with high rise buildings
MEGACO	Media Gateway Control IETF working group. See www.ietf.org for details.
MG	The media gateway provides the bearer circuit interfaces to the PSTN and transcodes the media stream.
MGC	An Media Gateway Controller is the overall controller function of the PSTN gateway. It receives, controls and mediates call signaling information between the PacketCable and PSTN.
MGCP	Media Gateway Control Protocol. Protocol follow on to SGCP.
MIB	Management Information Base
MIC	Message integrity code, a fixed length data item that is sent together with a message to ensure integrity, also known as a MAC.
MMC	Multi-Point Mixing Controller. A conferencing device for mixing media

	streams of multiple connections.
MSO	Multi-System Operator, a cable company that operates many head-end locations in several cities.
MSU	Message Signal Unit
MTA	Media Terminal Adapter – contains the interface to a subscribers' CPE, a network interface, CODECs, and all signaling and encapsulation functions required for VoIP transport, class features signaling, and QoS signaling.
MTP	The Message Transfer Part is a set of two protocols (MTP 2, 3) within the SS7 suite of protocols that are used to implement physical, data link and network level transport facilities within an SS7 network.
MWD	Maximum Waiting Delay
NANP	North American Numbering Plan. The set of rules for assigning phone numbers in North America.
NAT	Network Address Translation
NAT Network Layer	Network Address Translation Layer 3 in the Open System Interconnection (OSI) architecture; the layer that provides services to establish a path between open systems.
Network Management	The functions related to the management of data across the network.
NCS	Network Call Signaling
Nonce	A random value used only once which is sent in a communications protocol exchange to prevent replay attacks.
Non-Repudiation	The ability to prevent a sender from denying later that he or she sent a message or performed an action.
NPA-NXX	Numbering Plan Area (more commonly known as area code) NXX (sometimes called exchange) represents the next three numbers of a phone number. The N can be any number from 2-9 and the Xs can be any number. The combination of a phone number's NPA-NXX will usually indicate the physical location of the call device. The exceptions include toll-free numbers and ported number (see LNP)
NTP	Network Time Protocol, an internet standard used for synchronizing clocks of elements distributed on an IP network
NTSC	National Television Standards Committee which defines the analog color television, broadcast standard used today in North America.
Off-Net Call	Call connecting a PacketCable subscriber out to a user on the PSTN
On-Net Call	Call placed by one customer to another customer entirely on the PacketCable Network
One-way Hash	A hash function that has an insignificant number of collisions upon output.
OSP	Operator Service Provider
OSS	Operations Systems Support. The back office software used for configuration, performance, fault, accounting and security management.
PAL	Phase Alternate Line – the European color television format which evolved from the American NTSC standard.
PDU	Protocol Data Unit
PKCS	Public Key Cryptography Standards, published by RSA Data Security Inc. Describes how to use public key cryptography in a reliable, secure and interoperable way.

PKI	Public Key Infrastructure - a process for issuing public key certificates, which includes standards, Certification Authorities, communication between authorities and protocols for managing certification processes.
PKINIT	The extension to the Kerberos protocol that provides a method for using public key cryptography during initial authentication.
PHS	Payload Header Suppression, a DOCSIS technique for compressing the Ethernet, IP and UDP headers of RTP packets.
Plaintext	The original (unencrypted) state of a message or data.
Pre-shared Key	A shared secret key passed to both parties in a communication flow, using an unspecified manual or out-of-band mechanism.
Privacy	A way to ensure that information is not disclosed to any one other then the intended parties. Information is usually encrypted to provide confidentiality. Also known as confidentiality.
Private Key	The key used in public key cryptography that belongs to an individual entity and must be kept secret.
Proxy	A facility that indirectly provides some service or acts as a representative in delivering information there by eliminating a host from having to support the services themselves.
PSC	Payload Service Class Table, a MIB table that maps RTP payload Type to a Service Class Name.
PSFR	Provisioned Service Flow Reference. An SFR that appears in the DOCSIS configuration file.
PSTN	Public Switched Telephone Network.
Public Key	The key used in public key cryptography that belongs to an individual entity and is distributed publicly. Other entities use this key to encrypt data to be sent to the owner of the key.
Public Key Certificate	A binding between an entity's public key and one or more attributes relating to its identity, also known as a digital certificate.
Public Key Cryptography	A procedure that uses a pair of keys, a public key and a private key for encryption and decryption, also known as asymmetric algorithm. A user's public key is publicly available for others to use to send a message to the owner of the key. A users private key is kept secret and is the only key which can decrypt messages sent encrypted by the users public key.
PCM	Pulse Code Modulation – A commonly employed algorithm to digitize an analog signal (such as a human voice) into a digital bit stream using simple analog to digital conversion techniques.
QCIF	Quarter Common Intermediate Format
QoS	Quality of Service, guarantees network bandwidth and availability for applications.
RADIUS	Remote Access Dial-In User Service, an internet protocol (RFC 2138 and RFC 2139) originally designed for allowing users dial-in access to the internet through remote servers. Its flexible design has allowed it to be extended well beyond its original intended use
RAS	Registration, Admissions and Status. RAS Channel is an unreliable channel used to convey the RAS messages and bandwidth changes between two H.323 entities.
RC4	A variable key length stream cipher offered in the ciphersuite, used to encrypt the media traffic in PacketCable.

RFC	Request for Comments. Technical policy documents approved by the IETF which are available on the World Wide Web at http://www.ietf.cnri.reston.va.us/rfc.html
RFI	The DOCSIS Radio Frequency Interface specification.
RJ-11	Standard 4-pin modular connector commonly used in the United States for connecting a phone unit into the wall jack
RKS	Record Keeping Server, the device which collects and correlates the various Event Messages
Root Private Key	The private signing key of the highest level Certification Authority. It is normally used to sign public key certificates for lower-level Certification Authorities or other entities.
Root Public Key	The public key of the highest level Certification Authority, normally used to verify digital signatures that it generated with the corresponding root private key.
RSA Key Pair	A public/private key pair created for use with the RSA cryptographic algorithm.
RSVP	Resource reSerVation Protocol
RTCP	Real Time Control Protocol
RTO	Retransmission Timeout
RTP	Real Time Protocol, a protocol defined in RFC 1889 for encapsulating encoded voice and video streams.
S-MTA	Standalone MTA – a single node which contains an MTA and a non DOCSIS MAC (e.g. ethernet).
SA	Security Association - a one-way relationship between sender and receiver offering security services on the communication flow .
SAID	Security Association Identifier - uniquely identifies SAs in the BPI+ security protocol, part of the DOCSIS 1.1 specification.
SCCP	The Signaling Connection Control Part is a protocol within the SS7 suite of protocols that provides two functions in addition to those that are provided within MTP. The first is the ability to address applications within a signaling point. The second function is Global Title Translation.
SCP	A Service Control Point is a Signaling Point within the SS7 network, identifiable by a Destination Point Code, that provides database services to the network.
SCTP	Simple Control Transmission Protocol.
SDP	Session Description Protocol.
SDU	Service Data Unit. Information that is delivered as a unit between peer service access points.
Secret Key	The cryptographic key used in a symmetric key algorithm, which results in the secrecy of the encrypted data depending solely upon keeping the key a secret, also known as a symmetric key.
Session Key	A cryptographic key intended to encrypt data for a limited period of time, typically between a pair of entities.
SF	Service Flow. A unidirectional flow of packets on the RF interface of a DOCSIS system.
SFID	Service Flow ID, a 32-bit integer assigned by the CMTS to each DOCSIS Service Flow defined within a DOCSIS RF MAC domain. Any 32-bit SFID

	must not conflict with a zero-extended 14-bit SID. SFIDs are considered to be in either the upstream direction (USFID) or downstream direction (DSFID). USFIDs and DSFIDs are allocated from the same SFID number space.
SFR	Service Flow Reference, a 16-bit message element used within the DOCSIS TLV parameters of Configuration Files and Dynamic Service messages to temporarily identify a defined Service Flow. The CMTS assigns a permanent SFID to each SFR of a message.
SG	Signaling Gateway. A SG is a signaling agent that receives/sends SCN native signaling at the edge of the IP network.
SGCP	Simple Gateway Control Protocol. Earlier draft of MGCP.
SHA – 1	Secure Hash Algorithm 1 - a one-way hash algorithm.
SID	Service ID. A 14-bit number assigned by a CMTS to identify an upstream virtual circuit. Each SID separately requests and is granted the right to use upstream bandwidth.
Signed and Sealed	An “envelope” of information which has been signed with a digital signature and sealed by using encryption.
SIP	Session Initiation Protocol is an application layer control (signaling) protocol for creating, modifying and terminating sessions with one or more participants.
SNMP	Simple Network Management Protocol
SOHO	Small Office/Home Office
SPI	Security Parameters Index - a field in the IPSEC header that along with the destination IP address provides a unique number for each SA.
SS7	Signaling System Number 7. SS7 is an architecture and set of protocols for performing out-of-band call signaling with a telephone network.
SSP	Service Switching Point. SSPs are points within the SS7 network that terminate SS7 signaling links and also originate, terminate, or tandem switch calls.
STP	Signal Transfer Point. An STP is a node within an SS7 network that routes signaling messages based on their destination address. It is essentially a packet switch for SS7. It may also perform additional routing services such as Global Title Translation.
Subflow	A unidirectional flow of IP packets characterized by a single source and destination IP address and source and destination UDP/TCP port.
Symmetric Key	The cryptographic key used in a symmetric key algorithm, which results in the secrecy of the encrypted data depending solely upon keeping the key a secret, also known as a secret key.
Systems Management	Functions in the application layer related to the management of various open systems Interconnection (OSI) resources and their status across all layers of the OSI architecture.
TCAP	Transaction Capabilities Application Protocol. A protocol within the SS7 stack that is used for performing remote database transactions with a Signaling Control Point.
TCP	Transmission Control Protocol
TD	Timeout for Disconnect
TFTP	Trivial File Transfer Protocol
TFTP-D	Default – Trivial File Transfer Protocol

TGS	Ticket Granting Server used to grant Kerberos tickets.
TGW	Telephony Gateway
TIPHON	Telecommunications & Internet Protocol Harmonization Over Network.
TLV	Type-Length-Value tuple within a DOCSIS configuration file.
TN	Telephone Number
ToD	Time of Day Server
TOS	Type of Service. An 8-bit field of every IP version 4 packet. In a Diffserv domain, the TOS byte is treated as the Diffserv Code Point, or DSCP.
Transit Delays	The time difference between the instant at which the first bit of a PDU crosses one designated boundary, and the instant at which the last bit of the same PDU crosses a second designated boundary.
Trunk	An analog or digital connection from a circuit switch which carries user media content and may carry telephony signaling (MF, R2, etc.).
TSG	Trunk Subgroup
Tunnel Mode	An IPSEC (ESP or AH) mode that is applied to an IP tunnel, where an outer IP packet header (of an intermediate destination) is added on top of the original, inner IP header. In this case, the ESP or AH transform treats the inner IP header as if it were part of the packet payload. When the packet reaches the intermediate destination, the tunnel terminates and both the outer IP packet header and the IPSEC ESP or AH transform are taken out.
UDP	User Datagram Protocol, a connectionless protocol built upon Internet Protocol (IP).
Upstream	The direction from the subscriber location toward the head-end.
VAD	Voice Activity Detection
VBR	Variable bit-rate
VoIP	Voice over IP
WBEM	Web-Based Enterprise Management (WBEM) is the umbrella under which the DMTF (Desktop Management Task Force) will fit its current and future specifications. The goal of the WBEM initiative is to further management standards using Internet technology in a manner that provides for interoperable management of the Enterprise. There is one DMTF standard today within WBEM and that is CIM (Common Information Model). WBEM compliance means adhering to the CIM. See www.dmtf.org
X.509 certificate	a public key certificate specification developed as part of the ITU-T X.500 standards directory

Appendix D. Example Delay Budgets

A model that estimates delay and jitter for PacketCable networks is shown in the following charts. This information is for informative purpose only.

VoIP over DOCSIS Delay & Jitter Model

John T. Chapman, jchapman@cisco.com V2.1, 9/8/99 (v1.0 5/3/98)

Scenario:	A	B	C	D	E	F	G	H	I	J	K	L	
Voice Coding:	G.711T	G.728T	G.729T	G.711T	G.728T	G.729T	G.711	G.728	G.729	G.711	G.728	G.729	
Voice per Packet (ms):	10	10	10	20	20	20	10	10	10	20	20	20	
Delay Round Trip													
Codec:													
No Grant Sync:	25	30	39	35	40	49	32	45	50	42	55	60	ms
Grant Sync:	25	30	39	35	40	49	32	45	50	42	55	60	ms
Cable Plant:													
No Grant Sync:	15	15	15	25	25	25	15	15	15	25	25	25	ms
Grant Sync:	9	9	9	9	9	9	9	9	9	9	9	9	ms
Backbone:	210	210	210	210	210	210	210	210	210	210	210	210	ms
BTI <-> BTI													
No Grant Sync:	290	300	318	331	340	358	304	330	340	345	370	380	ms
Grant Sync:	278	288	306	299	308	326	292	318	328	313	338	348	ms
PSTN <-> BTI													
No Grant Sync:	275	285	303	305	315	333	289	315	325	319	345	355	ms
Grant Sync:	269	279	297	289	299	317	283	309	319	303	329	339	ms
Jitter One Way													
Coder:	0	0	0	0	0	0	0	0	0	0	0	0	ms
Cable Plant Upstream:													
No Grant Sync:	3	3	3	3	3	3	3	3	3	3	3	3	ms
Grant Sync:	3	3	3	3	3	3	3	3	3	3	3	3	ms
Backbone:	10	10	10	10	10	10	10	10	10	10	10	10	ms
Cable Plant Downstream:	1	1	1	1	1	1	1	1	1	1	1	1	ms
Decoder:	0	0	0	0	0	0	0	0	0	0	0	0	ms
BTI -> BTI													
No Grant Sync:	14	14	14	14	14	14	14	14	14	14	14	14	ms
Grant Sync:	14	14	14	14	14	14	14	14	14	14	14	14	ms
BTI -> PSTN													
No Grant Sync:	13	13	13	13	13	13	13	13	13	13	13	13	ms
Grant Sync:	13	13	13	13	13	13	13	13	13	13	13	13	ms
PSTN -> BTI	11	11	11	11	11	11	11	11	11	11	11	11	ms

Jitter Model Used: Case 1: Correlated

Delay Analysis:

Scenario:	A	B	C	D	E	F	G	H	I	J	K	L		Variable?
Voice Coding:	G.711T	G.728T	G.729T	G.711T	G.728T	G.729T	G.711	G.728	G.729	G.711	G.728	G.729		
Voice per Packet (ms):	10	10	10	20	20	20	10	10	10	20	20	20		c/v
Coder														
Codec Tx Look Ahead:	0.0	0.0	5.0	0.0	0.0	5.0	5.0	0.0	5.0	5.0	0.0	5.0	ms	
Tx Processing Delay:	0.0	2.5	4.0	0.0	2.5	4.0	1.0	10.0	10.0	1.0	10.0	10.0	ms	
Packetization:	10.0	10.0	10.0	20.0	20.0	20.0	10.0	10.0	10.0	20.0	20.0	20.0	ms	
Sub-Total:	**10.0**	**12.5**	**19.0**	**20.0**	**22.5**	**29.0**	**16.0**	**20.0**	**25.0**	**26.0**	**30.0**	**35.0**	**ms**	
CM -> CMTS														
Bytes per Frame:	109.0	49.0	39.0	189.0	69.0	49.0	109.0	49.0	39.0	189.0	69.0	49.0	bytes	
Upstream Rate:	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	Mbps	
CM prop Time:	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	ms	v
Upstream Playout Time:	0.3	0.2	0.1	0.6	0.2	0.2	0.3	0.2	0.1	0.6	0.2	0.2	ms	
Grant Arrival Uncertainty:														
-> no Grant Sync:	8.0	8.0	8.0	18.0	18.0	18.0	8.0	8.0	8.0	18.0	18.0	18.0	ms	
-> with Grant Sync:	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	ms	
Grant Window:	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	ms	v
uBR prop time:	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	ms	v
Cable Plant prop time:	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	ms	
Sub-Total no GS:	**12.3**	**12.1**	**12.0**	**22.5**	**22.1**	**22.1**	**12.3**	**12.1**	**12.0**	**22.5**	**22.1**	**22.1**	**ms**	
Sub-Total with GS:	**6.3**	**6.1**	**6.0**	**6.5**	**6.1**	**6.1**	**6.3**	**6.1**	**6.0**	**6.5**	**6.1**	**6.1**	**ms**	
Backbone														
# Switching Nodes:	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	nodes	
Delay per Node:	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	ms	
Node Prop Time:	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	ms	v
Specified Plant Delay:	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	95.0	ms	
Sub-Total:	**105.0**	**105.0**	**105.0**	**105.0**	**105.0**	**105.0**	**105.0**	**105.0**	**105.0**	**105.0**	**105.0**	**105.0**	**ms**	
CMTS -> CM														
Bytes per Frame:	149.0	89.0	79.0	229.0	109.0	89.0	149.0	89.0	79.0	229.0	109.0	89.0	bytes	
Downstream Rate:	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	Mbps	
uBR propagation time:	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	ms	v

Codec Parameters

	Row	G.711T	G.711	G.729T	G.729	G.728T	G.728	SC-10	G.723.1	G.722T	
Bit Rate	2	64	64	8	8	16	16	10	5.6	64	kbps
Frame Size	3	0	0	10	10	2.5	2.5	20	30	0	ms
Tx Look Ahead	4	0	5	5	5	0	0	18.5	7.5	0	ms
Tx Processing Delay	5	0	1	4	10	2.5	10	10	10	0	ms
Rx Processing Delay	6	0	1	5	10	2.5	10	10	10	0	ms

Global Variables

OH Bytes in u/s Frame:	29	bytes	Header Suppression On
OH Bytes in d/s Frame:	69	bytes	Header Suppression Off
Cable Plant Radius:	100	miles	
Minimum Jitter Buffer:	15	ms	
Jitter Model for Calculation	1	1,2,3	1 = correlated, 2 = only backbone correlated, 3 = uncorrelated

Notes:

=> Delay design goal is <= 300 ms
=> data input fields are marked in yellow with a black border
=> The CODEC "T" suffix refers to an optimized implemention with minimized processing delay
=> Non-T versions are a conservative implementation. "T" versions are an aggressive implementaiton and require development effort.
=> G.711 uses 5 ms look ahead for VAD
=> G.711T moves VAD look ahead into the packetization time, and optimizes DSP processing
=> G.729 assumes 5 ms of DSP power per channel for both rx and tx, a two channel implementation, and no process interleaving
=> G.729T assumes interleaving of packets
=> G.728 assumes 5 ms of DSP power per channel for both rx and tx, a two channel implementation, and no process interleaving
=> G.728T assumes optimized processing. Theoretical delay is 0.625. An extra 125 us was added for design margin
=> The processing delay of the DSP codec *must* be the worst case delay when handling multiple channels.
=> Over time as DSP horsepower increases, processing delay will decrease. Values are for DSP product of 1999.
=> The jitter buffer values are set equal to the max of measured jitter or minimum buffer size.
=> Jitter buffer is based upon CM to CM model, not PSTN to CM model.
=> Backbone budget may be 200 ms instead of 210 ms. This would free up 10 additional ms.
=> Jitter has been calculated 3 different ways:
1) correlated: All max jitter values are added together. This provides a worst case, but is not realistic
2) uncorrelated except the backbone: This allows a fixed jitter buget in the backbone to be added
to the rest of the uncorrelated delays
3) uncorrelated: All jitter sources are considered uncorrelated.

Appendix F

US 20010039600A1

(19) **United States**
(12) **Patent Application Publication** (10) **Pub. No.: US 2001/0039600 A1**
Brooks et al. (43) **Pub. Date: Nov. 8, 2001**

(54) **CABLE MODEM HAVING A PROGRAMMABLE MEDIA ACCESS CONTROLLER**

(76) Inventors: **John M. Brooks**, Niwot, CO (US); **Brett A. Bernath**, San Diego, CA (US)

Correspondence Address:
AKIN GUMP STRAUSS HAUER & FELD
1900 FROST BANK PLAZA
816 CONGRESS AVENUE
AUSTIN, TX 78701

(21) Appl. No.: **09/785,035**

(22) Filed: **Feb. 16, 2001**

Related U.S. Application Data

(63) Non-provisional of provisional application No. 60/183,130, filed on Feb. 17, 2000.

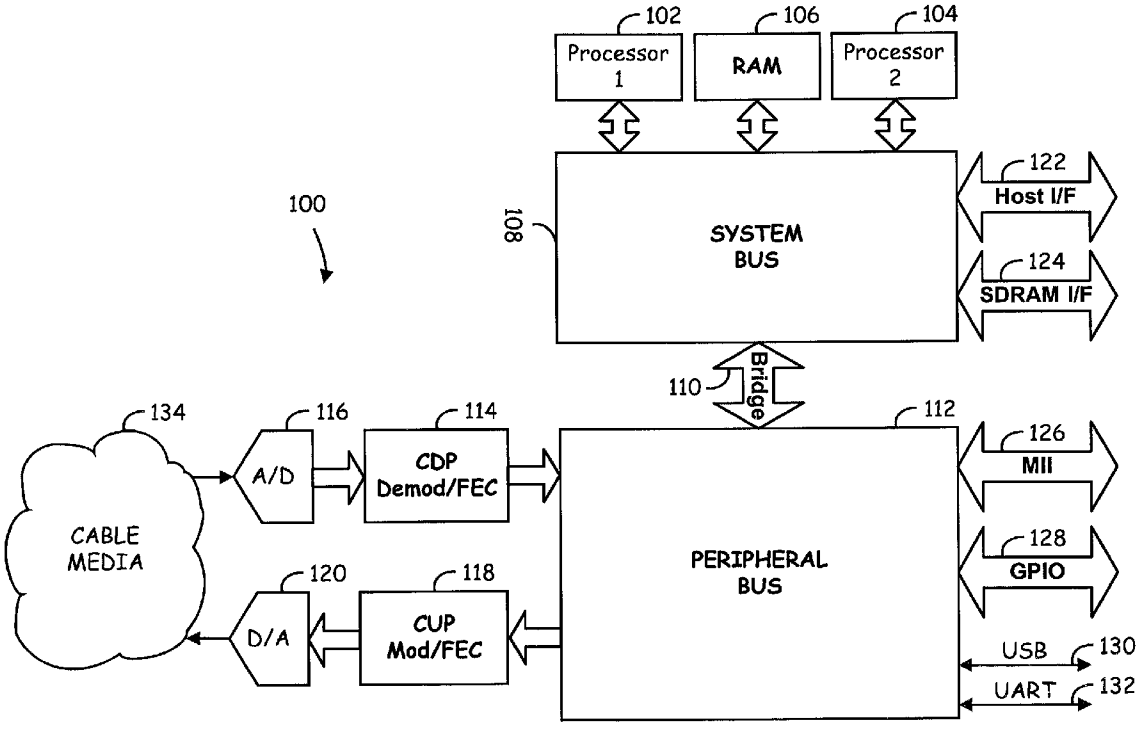
Publication Classification

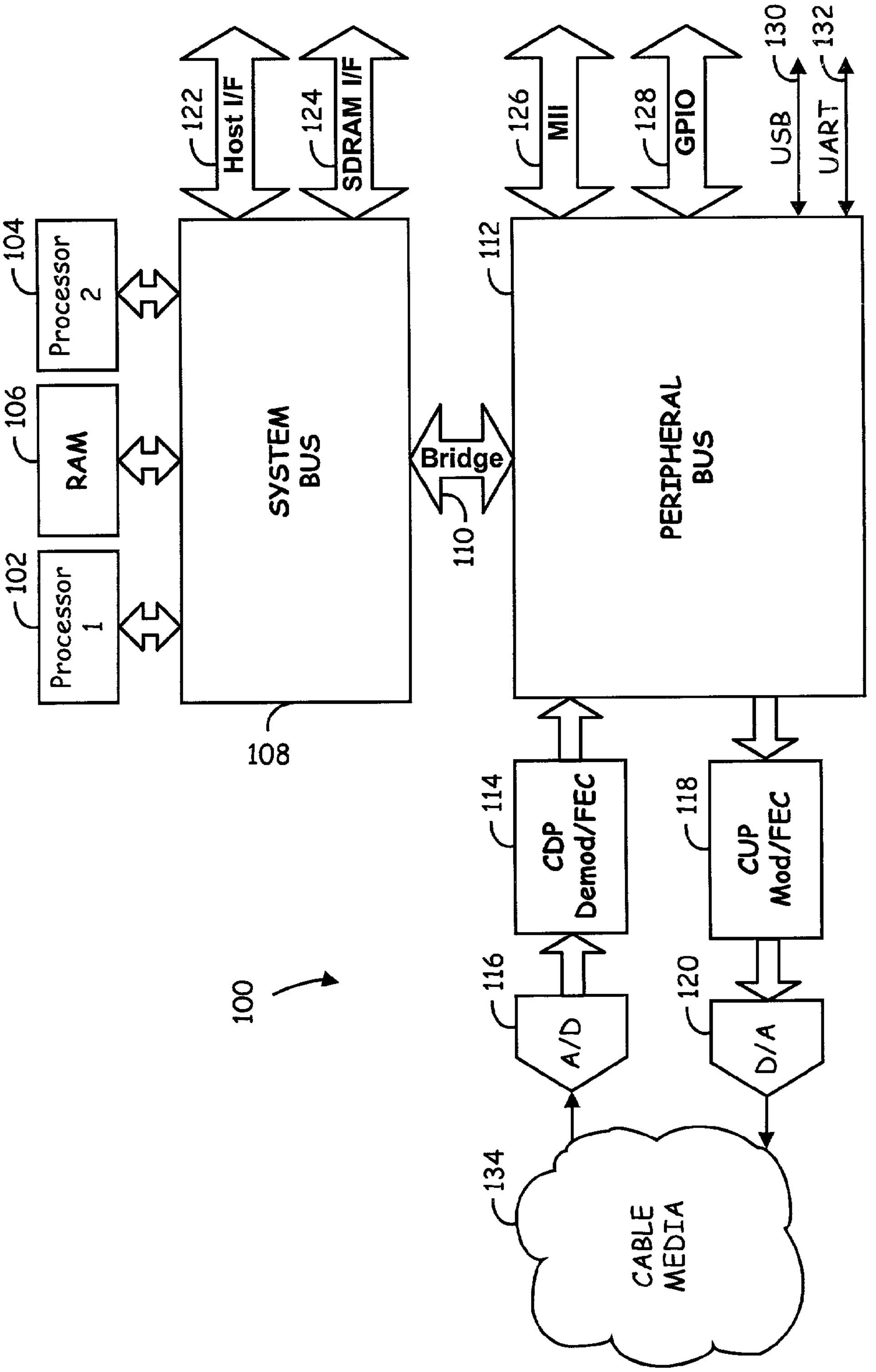
(51) **Int. Cl.**[7] **G06F 13/38**; G06F 13/40

(52) **U.S. Cl.** **710/126**

(57) **ABSTRACT**

A cable modem having a programmable media access controller (MAC). A single cable modem device includes all necessary MAC functions. The invention allows programmable MAC functions to support evolving standards (e.g., DOCSIS) without requiring expensive hardware upgrades. Bifurcated microprocessor architecture, in which first processing circuitry is programmed to implement MAC functionality for processing information flowing to and from cable media interface circuitry, and second embedded processor core or host system processor provides operating system functionality are used. Alternatively, separate processor cores provide MAC functionality for downstream and upstream data paths, respectively. Cable media interface circuitry, and other peripheral circuitry, are coupled to a peripheral bus that is linked by a bridge circuit to a system bus. The processing circuitry MAC is communicatively coupled to the system bus. Centralized DMA control directs data transfer between the peripheral and system buses as determined, at least in part, by the programmable MAC.





Processor 2
104
RAM
106
Processor 1
102
SYSTEM BUS
108
Host I/F
122
SDRAM I/F
124
Bridge
110
PERIPHERAL BUS
112
MII
126
GPIO
128
USB
130
UART
132
CDP Demod/FEC
114
CUP Mod/FEC
118
A/D
116
D/A
120
CABLE MEDIA
134
100

Fig. 1

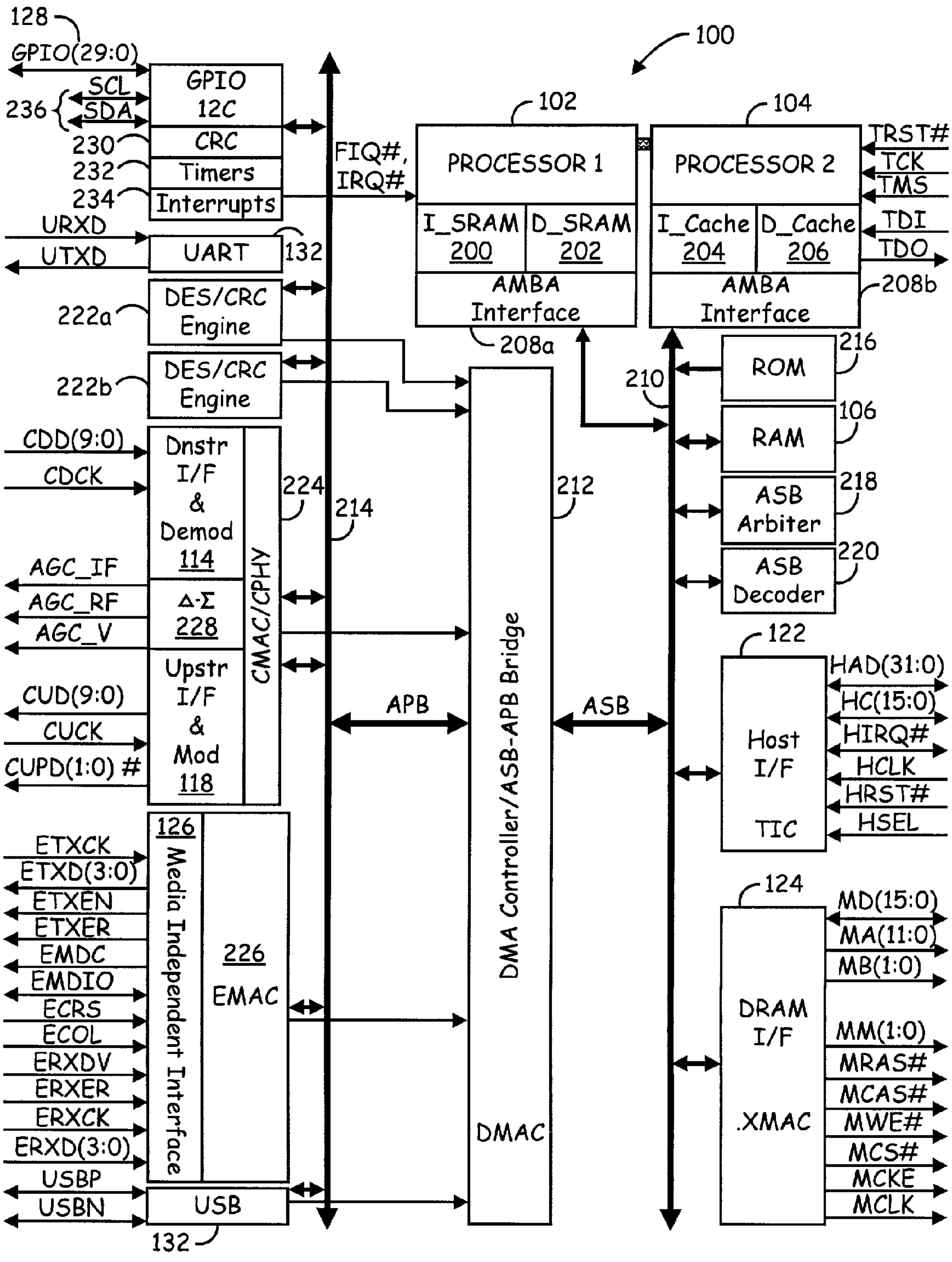

100
128
GPIO(29:0)
GPIO
I2C
236
SCL
SDA
230
CRC
232
Timers
234
Interrupts
FIQ#,
IRQ#
URXD
UTXD
UART
132
222a
DES/CRC
Engine
222b
DES/CRC
Engine
CDD(9:0)
CDCK
Dnstr
I/F
&
Demod
114
224
214
AGC_IF
AGC_RF
AGC_V
Δ-Σ
228
CMAC/CPHY
CUD(9:0)
CUCK
CUPD(1:0) #
Upstr
I/F
&
Mod
118
126
Media Independent Interface
226
EMAC
ETXCK
ETXD(3:0)
ETXEN
ETXER
EMDC
EMDIO
ECRS
ECOL
ERXDV
ERXER
ERXCK
ERXD(3:0)
USBP
USBN
USB
132
APB
102
PROCESSOR 1
I_SRAM
200
D_SRAM
202
AMBA
Interface
208a
212
DMA Controller/ASB-APB Bridge
DMAC
ASB
104
PROCESSOR 2
I_Cache
204
D_Cache
206
AMBA
Interface
208b
TRST#
TCK
TMS
TDI
TDO
210
ROM
216
RAM
106
ASB
Arbiter
218
ASB
Decoder
220
122
Host
I/F
TIC
HAD(31:0)
HC(15:0)
HIRQ#
HCLK
HRST#
HSEL
124
DRAM
I/F
XMAC
MD(15:0)
MA(11:0)
MB(1:0)
MM(1:0)
MRAS#
MCAS#
MWE#
MCS#
MCKE
MCLK

Fig. 2

Appendix F

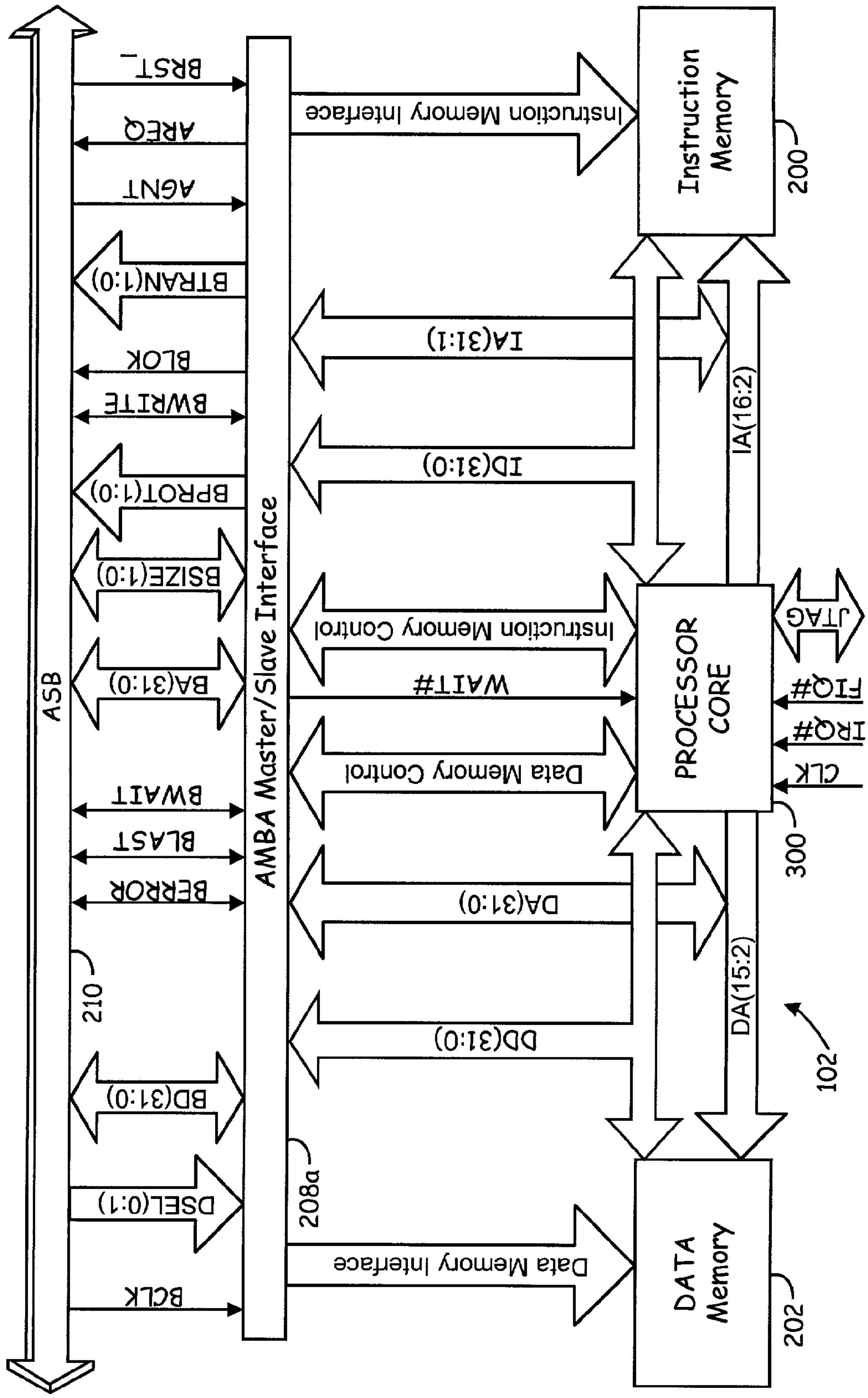
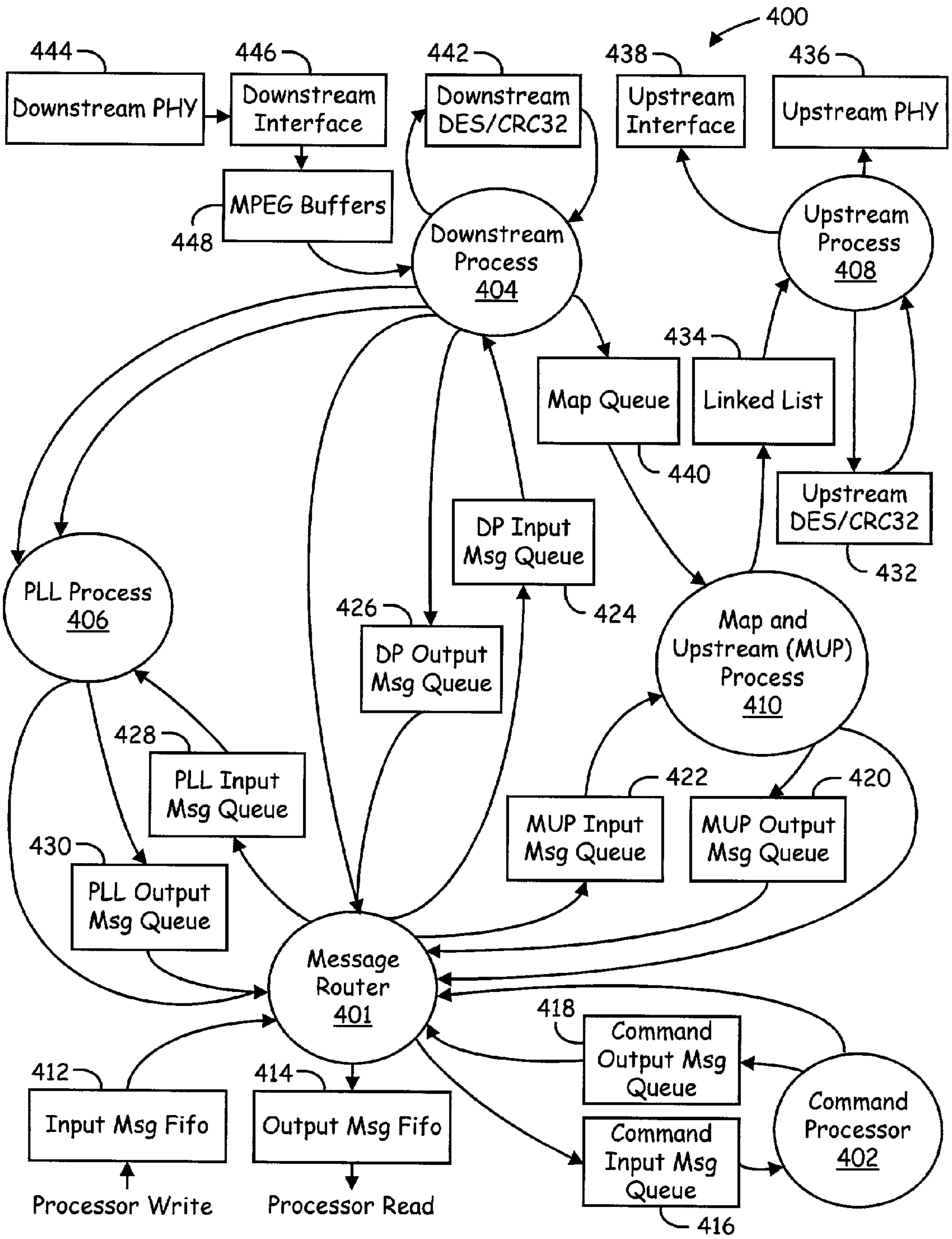


Fig. 3



400
444
Downstream PHY
446
Downstream Interface
442
Downstream DES/CRC32
438
Upstream Interface
436
Upstream PHY
MPEG Buffers
448
Downstream Process 404
Upstream Process 408
434
Map Queue
Linked List
440
Upstream DES/CRC32
432
DP Input Msg Queue
424
PLL Process 406
426
DP Output Msg Queue
Map and Upstream (MUP) Process 410
428
PLL Input Msg Queue
422
420
MUP Input Msg Queue
MUP Output Msg Queue
430
PLL Output Msg Queue
Message Router 401
418
Command Output Msg Queue
Command Processor 402
412
Input Msg Fifo
414
Output Msg Fifo
Command Input Msg Queue
416
Processor Write
Processor Read

Fig. 4

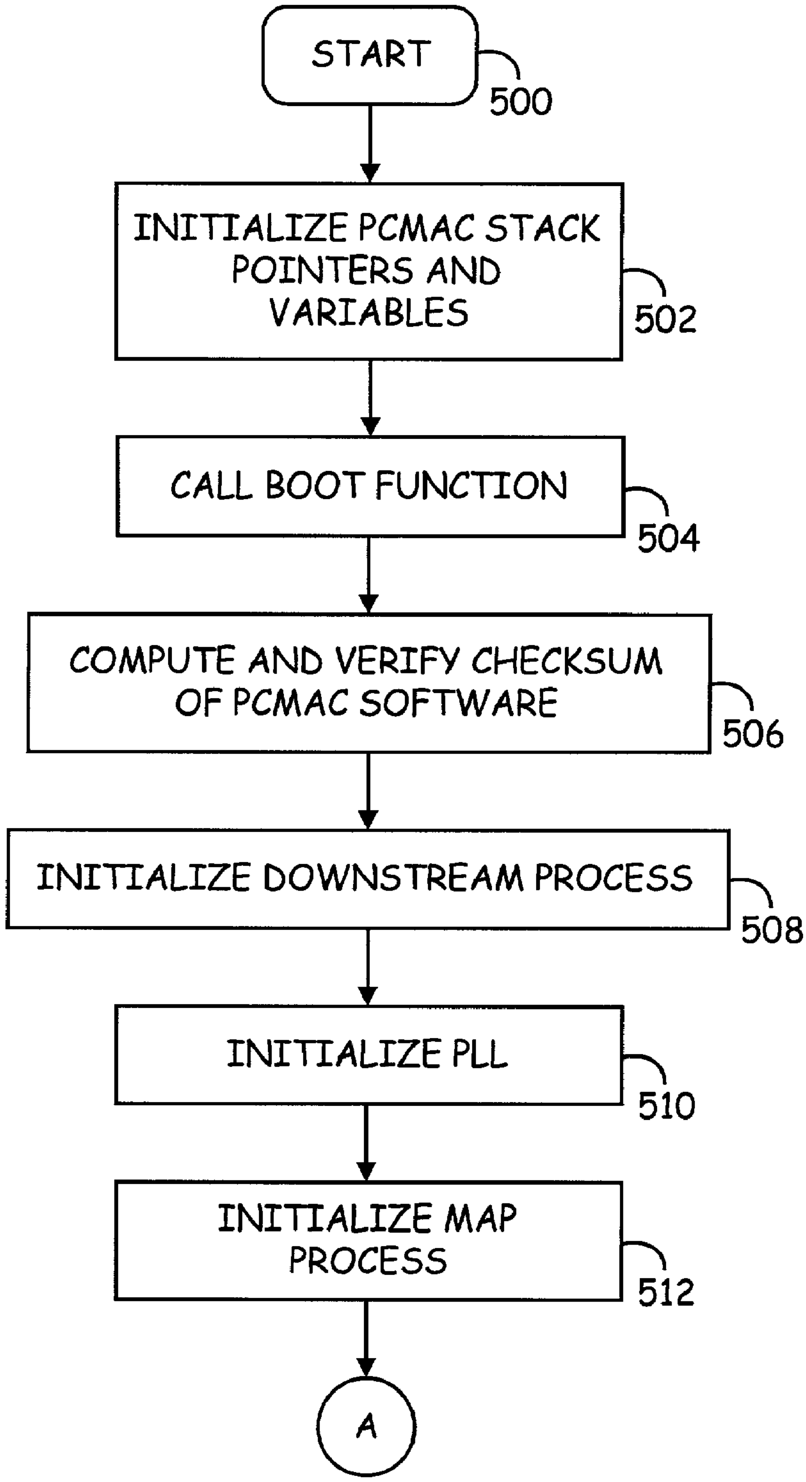

START
500
INITIALIZE PCMAC STACK POINTERS AND VARIABLES
502
CALL BOOT FUNCTION
504
COMPUTE AND VERIFY CHECKSUM OF PCMAC SOFTWARE
506
INITIALIZE DOWNSTREAM PROCESS
508
INITIALIZE PLL
510
INITIALIZE MAP PROCESS
512
A

Fig. 5A

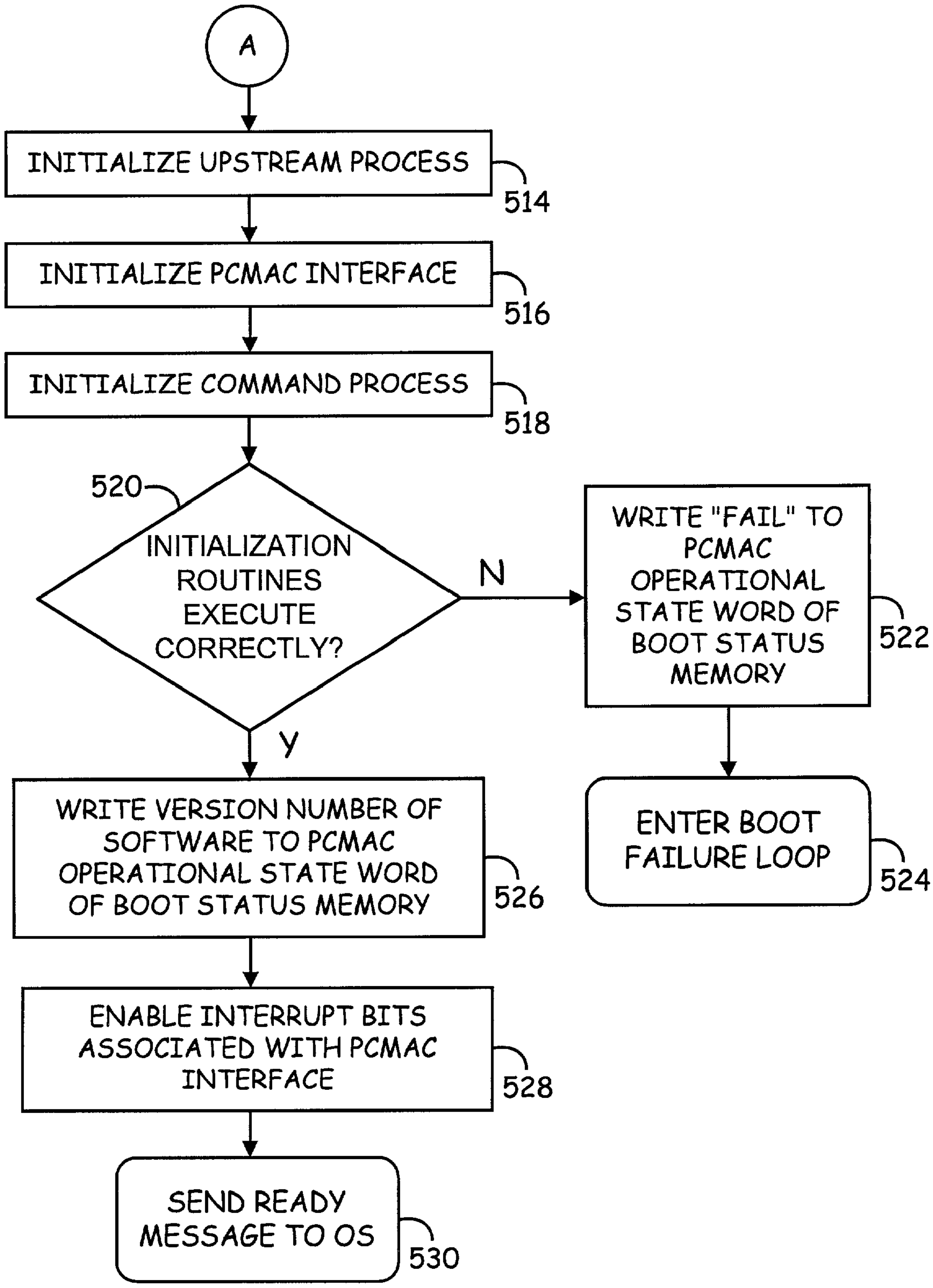

A
INITIALIZE UPSTREAM PROCESS
514
INITIALIZE PCMAC INTERFACE
516
INITIALIZE COMMAND PROCESS
518
520
INITIALIZATION ROUTINES EXECUTE CORRECTLY?
N
WRITE "FAIL" TO PCMAC OPERATIONAL STATE WORD OF BOOT STATUS MEMORY
522
ENTER BOOT FAILURE LOOP
524
Y
WRITE VERSION NUMBER OF SOFTWARE TO PCMAC OPERATIONAL STATE WORD OF BOOT STATUS MEMORY
526
ENABLE INTERRUPT BITS ASSOCIATED WITH PCMAC INTERFACE
528
SEND READY MESSAGE TO OS
530

Fig. 5B

CABLE MODEM HAVING A PROGRAMMABLE MEDIA ACCESS CONTROLLER

BACKGROUND

[0001] 1. Technical Field

[0002] The present invention relates generally to a cable modem; and, more particularly, it relates to a cable modem having a programmable media access controller.

[0003] 2. Related Art

[0004] In recent years, cable television networks have become more widespread. A typical cable TV system can carry many television stations, and is effectively a high bandwidth system. Because of the increasing availability of cable television infrastructure, the use of television cables as the medium for computer data networks has the potential for giving users high bandwidth at a reasonable cost. A cable TV system, however, requires several enhancements in order to function as a data network.

[0005] In its classic form, a cable TV system carries information in only one direction—from the cable system headend to the individual user. The user interface to the system generally comprises a receiver such as a television or a stereo. The headend transmits television or stereo channels simultaneously. In general, the user has no influence on what is transmitted and can only choose among the channels the headend is transmitting.

[0006] In contrast, a data network carries data from the headend to the user (the downstream path) and from the user to the headend (the upstream path). The individual user requires equipment, such as a cable modem, that can both receive from the headend and transmit to it. A cable data network must be able to handle many individual users simultaneously, each of whom have control over what they receive and transmit.

[0007] Cable modems offer greatly improved bandwidth capable of delivering services hundreds, or even thousands, of times faster than conventional modems. Cable modems can achieve data-transfer rates of up to 40 Mbits/s by connecting directly to coaxial lines as opposed to dial-in modems, that use twisted-pair copper telephone lines.

[0008] In order for a cable TV network to operate as a data network, it requires a headend capable of both transmitting and receiving data. To ensure that each user receives the data they require, a network protocol must be implemented to allow independent users of the network to utilize the shared headend and the distribution network without interference from or receiving the data of other users.

[0009] The network protocol places requirements on both the headend and the user end. Generally, the headend serves as the network controller, and the user's cable modem must be able to respond to commands from the headend. In cable modems adhering to the well-known OSI reference model, the lowest layer is the Physical layer (PHY), while the next layer up is the Data Link layer. The Data Link layer is segmented into two parts, the Medium Access Controller (MAC), which interfaces with the PHY, and the Logical Link Control (LLC), which interfaces to the MAC and to higher layers. In general, the MAC and LLC provide the following Data Link functionality: transmit and receive data encapsulation, including framing (frame boundary delimitation, frame synchronization), addressing (management of source and destination address), and error detection (detection of physical medium transmission errors); and media access management, including collision avoidance and handling. A physical address or MAC address is a unique Data Link layer address that is assigned to every port or device that connects to a network. Other devices in the network use these addresses to locate specific ports in the network and to create and update routing tables and data structures.

[0010] In an effort to coordinate the development of multimedia high-speed data services and the interoperability of network devices, cable operators have formed the Multimedia Cable Network Systems (MCNS) Group in cooperation with the industry research and development consortium CableLabs. The MCNS group has promulgated the Data Over Cable Service Interface Specification (DOCSIS). Other standards, such as DAVIC/DVB have likewise been created. Such standards continue to evolve over time, with the frequent inclusion of additional feature sets.

[0011] Previously, integrated cable modem devices have only included physical-layer functions and a fixed-function MAC. These devices are generally compliant with a single specification or a version of a specification. Thus, any changes to the underlying specification require hardware modifications for the MAC to be compliant, resulting in lengthy and expensive product development cycles.

[0012] Further limitations and disadvantages of conventional and traditional systems will become apparent to one of skill in the art through comparison of such systems with the present invention as set forth in the remainder of the present application with reference to the drawings.

SUMMARY OF THE INVENTION

[0013] Briefly, the present invention relates to a cable modem having a programmable media access controller (MAC). In one embodiment of the invention, a single cable modem device is provided that includes all necessary MAC functions. The cable modem device advantageously allows the MAC functions to be programmed to support evolving standards (e.g., DOCSIS) without requiring expensive hardware upgrades. The cable modem device may also include data-conversion components, a complete PHY that is compliant with both United States and European standards, an Ethernet MAC, a Universal Serial Bus (USB) transceiver, an encryption engine(s), key memory components and other peripheral functions.

[0014] The cable modem device of a disclosed embodiment of the invention utilizes a bifurcated microprocessor architecture in which first processing circuitry (e.g., an embedded processor core) is programmed to implement the desired MAC functionality for processing information flowing to and from cable media interface circuits. A second embedded processor core or host system processor provides operating system functionality and controls the boot process for the first embedded processor core. In a further embodiment, separate processor cores are provided for implementing MAC functionality for the downstream and upstream data paths, respectively. The embedded microprocessor cores may be Advanced RISC Machines (ARM) microprocessors or any other suitable microprocessor cores.

[0015] In a disclosed embodiment of the invention, cable media interface circuitry, as well as other peripheral cir-

cuitry, are coupled to a peripheral bus. The peripheral bus is linked by a bridge circuit to a system bus. The processing circuitry of the programmable MAC is communicatively coupled to the system bus. A novel centralized DMA controller is provided to direct transfer of data between the peripheral bus and the system bus as determined, at least in part, by the programmable MAC.

[0016] A cable modem device having a programmable MAC according to the present invention provides a software upgrade path to permit support for new versions of standards as they are adapted. Further, the programmable nature of the cable modem device permits individual manufacturers to differentiate products at the MAC layer without having to modify or replace hardware.

[0017] Other aspects, advantages and novel features of the present invention will become apparent from the following detailed description of the invention when considered in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] A better understanding of the present invention can be obtained when the following detailed description of various exemplary embodiments is considered in conjunction with the following drawings:

[0019] **FIG. 1** is a block diagram of an exemplary cable modem device having a programmable cable media access controller according to the present invention;

[0020] **FIG. 2** is a schematic block diagram providing exemplary details of the cable modem device of **FIG. 1**;

[0021] **FIG. 3** is a schematic block diagram providing exemplary details of processing circuitry of **FIG. 1** capable of being programmed to implement media access controller functionality in accordance with the present invention;

[0022] **FIG. 4** is a state diagram providing details of an exemplary programmable cable media access controller software architecture implemented by the cable modem device of **FIG. 1**; and

[0023] **FIGS. 5A and 5B** are flow diagrams of an exemplary boot process for a programmable cable media access controller according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0024] **FIG. 1** is a block diagram of an exemplary cable modem device **100** having a programmable cable media access controller (hereinafter referred to as a programmable MAC) in accordance with the present invention. The cable modem device **100** permits MAC functions to be programmed to support evolving standards, such as DOCSIS, without concomitant hardware upgrades. The disclosed circuitry may be part of a single integrated circuit, or a combination of integrated circuits. Alternatively, host system circuitry may be leveraged to perform certain of the functions described below.

[0025] The cable modem device **100** can be implemented in a variety of products, including external or internal cable modems with Ethernet and/or USB connections, multifunction home-networking products, interactive set-top-box solutions, digital satellite receivers, wireless networking devices having antennas, Small Office/Home Office (SOHO) equipment and Internet Protocol (IP) telephony products. Accordingly, various embodiments of the invention may interface with non-traditional "cable" media (e.g., any type of media capable of transporting MPEG packets), and the precise nature of the data transmission media is not considered critical to the invention. The cable modem device **100** may be compliant with any of a number of standards, including but not limited to, DOCSIS, DAVIC/DVB (Digital Video Broadcasting) and Voice Over IP (VOIP) standards. In the case of DOCSIS, typical MAC functionality includes MPEG and MCNS decoding and frame synchronization.

[0026] In the cable modem device **100** of **FIG. 1, a** first processor **102** is programmed to implement the desired MAC functionality, while a second processor **104** provides operating system support. The first processor **102** of the disclosed embodiment is designed for high performance data processing. In addition to executing an operating system, the second processor **104** may manage some message processing and scheduling. The second processor **104** preferably utilizes a real-time operating system, such as VxWorks®.

[0027] Data passed between the first and second processors **102** and **104** and other components of the cable modem device **100** may be stored in random access memory (RAM) **106**. The RAM **106**, as well as the first and second processors **102** and **104**, are communicatively coupled to a system bus **108**. The system bus **108** is linked to a peripheral bus **112** via a bridge **110**.

[0028] Bi-directional communication between the cable modem device **100** and cable media **134** is conducted by physical layer devices coupled to the peripheral bus **112**. More particularly, downstream data communicated from the cable media **134** is received by analog-to-digital conversion circuitry **116**. The digital output of the analog-to-digital circuitry **116** is provided to a cable downstream PHY circuitry **114** that performs demodulation and forward error correction functions. The output of the cable downstream PHY circuitry **114** is provided to peripheral bus **112** for processing by the programmable MAC.

[0029] Upstream data to be communicated to the cable media **134** is provided from the peripheral bus **112** to cable upstream PHY circuitry **118** that modulates the upstream data, and may also perform error correction operations. The output of the cable upstream PHY circuitry **118** is communicated to a digital-to-analog converter **120** for provision to the cable media **134**.

[0030] The cable modem device **100** of **FIG. 1** may also include a number of optional interfaces for communicating with a host system or external devices. For example, a host interface **122** and expansion memory interface **124** may be coupled to the system bus **108**. Likewise, the peripheral bus **112** may support a Media Independent Interface (MII) **126**, a General Purpose Input/Output (GPIO) interface **128**, a USB port **130**, and a UART port **132**. As will be appreciated, many other types of interfaces may be provided, and the precise nature of supported devices is not considered critical to the invention.

[0031] Various alternate embodiments of the cable modem device **100** are contemplated. For example, the programmable MAC could be implemented by a pair of processors, with the upstream code handled by one processor and the

downstream code handled by another processor. Such a configuration may provide advantages in terms of software partitioning.

[0032] **FIG. 2** is a schematic block diagram providing exemplary details of the cable modem device **100** of **FIG. 1**. In this embodiment of the invention, the cable modem device **100** utilizes the Advanced System Bus (ASB **210**) and Advanced Peripheral Bus (APB **214**) protocol and bus architecture as specified in the Advanced Microcontroller Bus Architecture (AMBA) specification. The AMBA specification defines an on-chip communication standard for designing high-performance embedded microcontrollers. The ASB **210** is generally utilized for high-performance system modules, supporting the efficient connection of processors, on-chip memories, and off-chip external memory interfaces with low-power peripheral/macrocell functions. The APB **214** is generally utilized with low-power peripherals, and is optimized for minimal power consumption and reduced interface complexity in supporting peripheral functions.

[0033] Another bus defined by the AMBA specification is the Advanced High-Performance Bus (AHB). The AHB is generally utilized with high-performance, high-frequency system modules. The AHB may act as the high-performance system backbone bus, and supports the efficient connection of processors, on-chip memories, and off-chip external memory interfaces with low-power peripheral macrocell functions.

[0034] In the disclosed embodiment of the invention, the ASB **210** is utilized as the system bus **108**, although it is contemplated that other buses such as the AHB may also be used. The ASB **210** is the bus on which the first and second processors **102** and **104**, RAM memory **106**, and other direct memory access (DMA) devices reside. The ASB **210** provides a high-bandwidth interface between the system elements that are involved in the majority of data transfers. An ASB-APB bridge/centralized DMA controller **212** is provided for linking the ASB **210** to the lower bandwidth APB **214**, where most of the peripheral devices in the cable modem device **100** are located. As discussed in greater detail below, the ASB-APB bridge/centralized DMA controller **212** is both an ASB **210** master and an APB **214** master, and utilizes burst transfers and pipelining of data to optimize bus efficiency.

[0035] The APB **214** provides the basic peripheral macrocell communications infrastructure. Such peripherals typically have interfaces which are memory-mapped registers, have few high-bandwidth interfaces, and are accessed under program control (such as the programmable MAC). In the disclosed embodiment of the invention, certain performance enhancements have been made to the APB and ASB, as well as the device interfaces to these buses, as set forth in greater detail in previously incorporated patent applications entitled, "System and Method for Providing an Improved Synchronous Operation of an Advanced Peripheral Bus with Backward Compatibility", and "Asochronous Centralized Multi-Channel DMA Controller".

[0036] Although the disclosed cable modem device **100** utilizes the AMBA bus architecture, in a broader implementation the programmable MAC may be configured to operate with a wide variety of buses and interface with any type of peripheral device. For example, in a host processor-based implementation, the ASB **210** may be replaced with a PCI bus or other type of bus typically found in computer systems.

[0037] In this embodiment of the invention, the first processor **102** includes a microprocessor macrocell providing a high-performance integer core RISC engine that utilizes an instruction memory **200** and a data memory **202**. The second processor **104** of this embodiment is a cached microprocessor macrocell (e.g., an ARM940T macrocell by Advanced RISC Machines) providing a high-performance integer core RISC engine. The second processor **104** has a separate instruction cache **204** and data cache **206**, as well as a memory configuration and protection unit. The instruction and data caches **204** and **206** of the second processor **104** support concurrent processing. In addition, the second processor **104** is capable of performing random read/write ASB accesses and cache line fills, as well as buffered burst writes. The first processor **102** and second processor **104** communicate with the ASB **210** via an AMBA Interface **208***a* and **208***b*, respectively.

[0038] The first processor **102** and second processor **104** each have two interrupt inputs FIQ# and IRQ# that are active-low level-sensitive. In the disclosed embodiment of the invention, the FIQ# interrupt is of higher priority than the IRQ# interrupt and is serviced first when both interrupts are asserted in unison. Servicing an FIQ# interrupt disables an IRQ# interrupt until the FIQ# interrupt handler exits or re-enables the IRQ# interrupt.

[0039] In addition to RAM **106**, a read only memory (ROM) **216** may be provided on the ASB **210**. Further, an ASB arbiter **218** is coupled to the ASB **210**. The ASB arbiter **218** determines which ASB master has access to the ASB **210**. In this embodiment, there are four ASB masters capable of requesting the ASB **210**: the first processor **102**, the second processor **104**, the host interface **122**, and the DMA controller **212**. The arbitration scheme utilized by the ASB arbiter **218** is based on priority. The DMA controller **212** has the highest priority in order to minimize system latency and data buffering for certain peripherals. The host interface **122** has second priority since its access may be less frequent. The first processor **102** has next priority since its accesses may be generally more time critical than those of the second processor **104**. Of course, other arbitration schemes may be utilized.

[0040] The host interface **122** may also function as a test interface controller (TIC) that provides a parallel test access port to the first and second processor **102** and **104**, as well as the ASB **210**. The TIC allows externally applied test vectors to be converted into internal bus transfers. More than one host interface **122** may be maintained by the cable modem device **100**. For example, in addition to the host interface **122**, a PCI or similar interface may added for communicating to a host system, while the host interface **122** communicates with other peripherals such as voice attachments. The host interface **122** supports a slave mode which provides an external host processor access to its internal memory, as well as memory-mapped register set. The host interface **112** also supports a master mode which allows control signals to access external slave devices such as flash memory or data peripherals.

[0041] An ASB decoder **220** is also coupled to the ASB **210**. The ASB decoder **220** decodes addresses on the ASB

210, and provides selection signals to each ASB slave. The expansion memory interface **124** includes an expansion memory access controller (XMAC) that provides an interface to support external memory. In the disclosed embodiment of the invention, the expansion memory interface **124** is a 16-bit synchronous interface, although many variations are possible.

[**0042**] As previously mentioned, a number of physical interfaces to external data sources are coupled to the APB **214**. In particular, a cable media access controller (CMAC) **224**, including a system timer and interfaces to the cable downstream PHY circuitry **114** and cable upstream PHY circuitry **118**, is provided to support communications with a cable media **134**. The CMAC **224** hardware and firmware combine to support a desired specification (e.g., a DOCSIS feature set for the MAC sub-layer of an MCNS cable modem). In general, CMAC **224** aligns incoming packets and prepends a time stamp and appends a pattern recognition trailer structure to form word packets to be delivered to memory by the DMA controller **212**. The CMAC **224** is also responsible for requesting data from the DMA controller **212** at the appropriate time, calculating checksums, and encrypting all or part of the upstream data and bursting the data to the upstream cable upstream PHY circuitry **118**. Exemplary details of the later operation are provided in the previously-incorporated patent application entitled "Method and Apparatus for Upstream Burst Transmission Synchronization in Cable Modems." Delta sigma converter circuitry **228** is also coupled to the CMAC **224** to provide automatic gain control and other functionality for the cable PHY layer.

[**0043**] A pair of DES/CRC engines **222***a* and **222***b* are provided as peripherals to the APB **214**. The DES/CRC engines **222***a* and **222***b* are capable of performing DES encryption or decryption, and/or cyclic-redundancy-checks on a stream of data supplied by the DMA controller **212**. Providing more than one DES/CRC engine **222** permits a plurality of data flow threads to be processed simultaneously.

[**0044**] An Ethernet external datalink is also coupled to the APB **214**, and is comprised of an Ethernet media access controller (EMAC) **226** and the MII **126**. In the disclosed embodiment of the invention, the EMAC **226** supports the MAC sublayer of the IEEE 802.3 specification and allows it to be connected to an IEEE 802.3 10/100 Mbps (100Base-T and 10Base-T) MII compatible EPHY device or seven-wire HomeLan PHY device. The MII **126** provides a port to transmit and receive data that is media independent, multi-vendor interoperable, and supports all data rates and physical standards. The port consists of datapaths that are generally four bits wide in each direction, as well as control and management signals. The MII **126** can be configured as a glueless connection to support Ethernet or HomeLan serial mode.

[**0045**] A USB interface **132** is also coupled to the APB **214**. The USB interface **132** can couple to any of a number of compliant external devices. In the disclosed embodiment of the invention, the USB interface **132** supports receive and transmit signaling of 12-Mb/s.

[**0046**] A number of other miscellaneous peripherals may also be coupled to the APB **214**. For example, a UART **132** may be provided to receive and transmit data, for example, over a telephone line. In addition, a CRC engine **230** is provided to perform single-cycle computations on input data up to 32 bits at a time. This CRC engine **230** is intended to provide high-performance Header Check Sequence (HCS) calculations, as used in both downstream and upstream CMAC operations.

[**0047**] Programmable timer circuitry **232** is also coupled to the APB **214**, and may perform a number of functions. For example, the programmable timer circuitry **232** may generate real-time interrupts, as well as perform system "watchdog" operations. The programmable timer circuitry **232** may also be used as an external event counter.

[**0048**] A pair of interrupt controllers **234** may be provided, one for each of the first processor **102** and second processor **104**. All peripheral interrupt sources are routed through the interrupt controllers **234**, and reduced to two active low inputs to the first and second processors **102** and **104**—FIQ# and IRQ#—which are asserted in response to specified data operations. Software control interrupts may also be provided.

[**0049**] A general purpose I/O bus **128** and I^2C serial bus **236** are also coupled to the APB **214**. It is contemplated that two of the I/O pins of the general purpose I/O bus **128** may be enabled for software controlled I^2C operations via a control register. Pins of the general purpose I/O bus **128** can also serve as external interrupt inputs.

[**0050**] **FIG. 3** is a schematic block diagram providing exemplary details of the first processor **102** of **FIG. 1**. Again, the first processor **102** is capable of being programmed to implement MAC functionality in accordance with the present invention.

[**0051**] As discussed generally above, the first processor **102** comprises a processor core **300**, an instruction memory **200**, and a data memory **202**. Each of these elements communicates with the ASB **210** via the AMBA interface **208***a*. In one contemplated embodiment of the invention, the processor core **300** is a high-performance integer core such as that used in the ARM940T processor macrocell. In one embodiment of the invention, the instruction memory **200** comprises a 20K×32 SRAM coupled to the instruction address and data busses IA and ID. The data memory **202** of the this embodiment comprises a 12K×32 SRAM coupled to the data and address buses DD and DA.

[**0052**] Inputs to the processor core **300** include a JTAG test bus, a clock signal CLK, and the interrupts FIQ# and IRQ#. The processor core **300** also interfaces with an instruction memory control bus and data memory control bus coupled to the AMBA interface **208***a*. In accordance with the ASB specification, a number of control, address and data signals are communicated between the AMBA interface **208** and the ASB **210**.

[**0053**] **FIG. 4** is a state diagram providing details of an exemplary programmable MAC **400** software architecture implemented by the cable modem device **100** of **FIG. 1**. The programmable MAC **400** software of this embodiment of the invention is composed of several software processes that perform various tasks and functions. A number of the programmable MAC **400** processes communicate with each other via shared memory regions, functions, or subroutines. Other programmable MAC **400** processes communicate with the operating system via a programmable MAC interface. The programmable MAC interface may be imple-

mented as a reserved region of data memory or message queues, an interrupt controller, and predefined messages to pass data, configuration parameters, and status information across the interfaces. The programmable MAC **400** processes may span one or more processor contexts. Transitions between programmable MAC **400** processes may occur via external hardware interrupts (IRQ or FIQ), or via a software interrupt causing a change of context. In general, a process executing within a given context will execute linearly until completion or until another context switch occurs.

[**0054**] The exemplary programmable MAC **400** software of **FIG. 4** comprises six (6) major process: a message router process **401**, a command processor **402**, a downstream process **404**, a PLL process **406**, an upstream process **408**, and a map and upstream (MUP) process **410**. These processes are provided by way of example, and it is contemplated that a greater number or a fewer number of processes could be implemented without departing from the spirit or scope of the invention.

[**0055**] The message router **401** is primarily responsible for managing the flow of information into and out of the programmable MAC. This includes placing programmable MAC downstream data (protocol data units (PDU) and MAC management messages (MMM)) and status messages in the programmable MAC output message FIFO **414**. The message router **401** is also responsible for retrieving programmable MAC upstream data and configuration messages from the programmable MAC input message FIFO **412**. Messages retrieved by the message router **401** are then routed to the appropriate programmable MAC **400** process. The message router **401** is further responsible for managing programmable MAC status interrupts.

[**0056**] The message router **401** also interacts with a command processor that receives and processes MCNS and other commands. Commands directed to the command processor **402** are placed in the command input message queue **416**, while a command output message queue **418** is used to store output messages from the command processor **402**.

[**0057**] The downstream process **404** manages and monitors the flow of downstream data. More particularly, the downstream process **404** of the disclosed embodiment of the invention is responsible for: MPEG synchronization, MPEG frame header verification, MCNS frame header verification, extraction of MCNS extended header information, SID perfect filtering, MAC address perfect filtering, imperfect multi-cast address filtering, information element filter, DES decryption, CRC validation, downstream data transfer to the appropriate destination (PLL, MAP processor, or programmable MAC external interface), and downstream statistics.

[**0058**] Messages from the message router **401** to the downstream process **404** are placed in a downstream process input message queue **424**, while messages from the downstream process **404** to the message router **401** are placed in a downstream process output message queue **426**. The downstream process **404** communicates with a downstream PHY **440** via a downstream interface **446** and MPEG buffers **448**. The downstream process **404** further utilizes a downstream DES/CRC engine **442** to provide decryption and validation functionality.

[**0059**] The PLL process **406** functions to provide a local clock reference that is phase-locked to a CMTS clock. The PLL process **406** further provides conversion functions to convert between system time and the local hardwire time. In addition, the PLL process **406** communicates status information to the second processor **104** and the other programmable MAC processes. Messages from the message router **401** to the PLL process **406** are placed in a PLL input message queue **428**. Messages from the PLL process **406** to the message router **401** may be placed in a PLL output message queue **430**.

[**0060**] The upstream process **408** manages the transmission of upstream data. More particularly, the upstream process **408** handles: concatenation/fragmentation of upstream frames, checksum or CRC computation, DES encryption, programming the upstream physical layer or PHY **436**, and ensuring time-to-send requirements are met. The upstream process **408** utilizes an upstream DES/CRC function **432** to coordinate encryption and validation of upstream data. The upstream process **408** further communicates with an upstream interface **438**, and receives linked list data **434** from the MUP process **410**.

[**0061**] The MUP process **410** handles the processing of downstream MAP frames, manages the scheduling of upstream frame transmission, and handles the ranging process used to optimize communications with a cable headend. The MUP process **410** of the disclosed embodiment of the invention has two entry points: a MUP input message queue **422** that is called by the message router **401** when a new input message is available in the queue, and a MAP queue **440** that is called by the downstream process **404** when new MAP is available. MUP output message queue **420** is also provided for passing data to the message router **401**.

[**0062**] It is contemplated that additional functions may be added to the exemplary programmable MAC **400** software architecture of **FIG. 4**, and that other functions may be implemented in hardware.

[**0063**] **FIGS. 5A and 5B** are flow diagrams of an exemplary boot process for a programmable MAC according to the present invention. The boot process of the disclosed embodiment of the invention maintains a boot status memory area at a fixed address in memory to allow the second processor **104** to monitor the boot status of the programmable MAC. The boot status memory region preferably resides at a fixed, word-line address in the processor data memory. The programmable MAC updates words in the boot status region with non-zero values as it proceeds through the boot process. The boot process may be conducted by the second processor **104**, by a host system via a host system interface **122**, or by other circuitry of the cable modem device **100**.

[**0064**] Following commencement of the boot process at step **500**, the programmable MAC stack pointers and variables are initialized at step **502**. The programmable MAC can maintain separate stacks for each of the separate contexts or operating modes of the processor **102**. These stacks, as well as processor data memory variables, are initialized in this step.

[**0065**] Next, in step **504**, the boot process calls a boot function to perform the remainder of the disclosed programmable MAC boot process. The boot function of the boot process proceeds to step **506**, where a checksum is performed on the programmable MAC software loaded into the

processor instruction memory. The computed checksum is then compared to a value stored in a global memory variable. Next, beginning with step **508**, all programmable MAC software processes are initialized via initialization routines called by the boot process. The downstream process is first initialized in step **508**, followed by initialization of PLL in step **510**. The MAP process is next initialized in step **512**.

[**0066**] The boot process continues at step **514 (FIG. 5B)** where the upstream process is initialized. The programmable MAC interface is next initialized in step **516**, followed by initialization of the command process in step **518**.

[**0067**] Following initialization of the programmable MAC software processes, the boot process determines if the initialization routines executed correctly. If not, the boot process writes a "fail" value to the operating state word of the boot status memory. Next, a boot failure loop is entered in step **524**, although it is contemplated that step **522** may be performed upon entry into the boot failure loop. In addition, if the boot process fails, a power-on reset may be applied by the second processor **104**.

[**0068**] If the initialization routines executed correctly as determined in step **520**, the boot process proceeds to step **526** and a version number of the programmable MAC software is written to the operating state word of the boot state status memory. Next, in step **528**, the boot process enable interrupt bits associated with the programmable MAC interface or message router **401**. Finally, the boot process sends a message to the operating system indicating that the power on processes is complete and the programmable MAC is ready for operation.

[**0069**] Thus, a cable modem having a programmable MAC has been described. The programmable MAC features of the cable modem provide a software upgrade path to permit support for new versions and variations of cable modem standards, thereby reducing or eliminating hardware development costs.

[**0070**] In view of the above detailed description of the present invention and associated drawings, other modifications and variations will now become apparent to those skilled in the art. It should also be apparent that such other modifications and variations may be effected without departing from the spirit and scope of the present invention.

What is claimed is:

1. A cable modem having a programmable media access controller, comprising:

a system bus;

a plurality of processors, each of the plurality of processors is communicatively coupled to the system bus, that perform a plurality of processing functions, the plurality of processing functions are partitioned, at least in part, between at least two of the plurality of processors;

a peripheral bus that is operable to perform transfer of cable media;

a bridge that communicatively couples the system bus and the peripheral bus; and

a peripheral processing device, communicatively coupled to the peripheral bus, that is operable to perform processing of a selectively off-loaded portion of the cable media.

2. The cable modem of claim 1, wherein one of the plurality of processors supports upstream data transfer of cable media received by the cable modem; and

at least one other of the plurality of processors supports downstream data transfer of the cable media transmitted by the cable modem.

3. The cable modem of claim 1, wherein one of the plurality of processors is operable to perform at least one of message processing and scheduling.

4. The cable modem of claim 1, wherein the bridge comprises a direct memory access controller that is operable selectively to provide a portion of the cable media to one of the plurality of processors and to provide the off-loaded portion of the cable media to the peripheral processing device.

5. The cable modem of claim 1, further comprising at least one additional peripheral processing device, communicatively coupled to the peripheral bus, that is operable to perform processing of at least one additional selectively off-loaded portion of the cable media.

6. The cable modem of claim 1, wherein the plurality of processing functions comprises operating system functionality.

7. The cable modem of claim 1, wherein the plurality of processing functions comprises media access control functionality.

8. The cable modem of claim 1, wherein one of the plurality of processors employs embedded code to support media access control functionality.

9. A cable modem device, comprising:

a bifurcated bus structure comprising a first bus and a second bus;

a partitioned processor structure, communicatively coupled to the first bus, comprising a plurality of processors, that is operable to perform a plurality of processing functions;

a co-processor, communicatively coupled to the second bus, that is operable to support processing of cable media that is selectively off-loaded from at least one of the plurality of processors;

an input/output interface, communicatively coupled to the second bus, that is operable to perform data transfer of a plurality of data to the second bus; and

a direct memory access controller that communicatively couples the first bus and the second bus and that is operable to support off-loading of at least one function of the plurality of functions to the co-processor.

10. The cable modem device of claim 9, further comprising at least one additional coprocessor, communicatively coupled to the second bus, that is also operable to support processing of cable media that is selectively off-loaded from at least one of the plurality of processors.

11. The cable modem device of claim 9, wherein the first bus employs an Advanced System Bus protocol; and

the second bus employs an Advanced Peripheral Bus protocol.

12. The cable modem device of claim 9, wherein one of the plurality of processors supports upstream data transfer of cable media received by the cable modem; and

at least one other of the plurality of processors supports downstream data transfer of the cable media transmitted by the cable modem.

13. The cable modem device of claim 9, wherein the co-processor is operable to perform at least one of DES encryption and DES decryption.

14. The cable modem device of claim 9, wherein the plurality of processing functions comprises operating system functionality and media access control functionality.

15. The cable modem device of claim 9, wherein the second bus operates consuming power at a rate lower than a rate at which the first bus consumes power.

16. The cable modem device of claim 9 manufactured as an integrated circuit.

17. A method to perform processing within a cable modem, the method comprising:

performing cable media processing using a plurality of processors, the cable media processing is partitioned, at least in part, between at least two of the plurality of processors;

selectively off-loading a portion of the cable media from at least one of the plurality of processors to a co-processor; and

processing the off-loaded portion of the cable media using the co-processor.

18. The method of claim 17, wherein the method is performed within an integrated circuit.

19. The method of claim 17, wherein at least one of the plurality of processors comprises embedded code that is substantially operable for media access control functionality.

20. The method of claim 17, further comprising directing upstream and downstream communications of cable media using at least two of the plurality of processors.

* * * * *

Appendix G

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/675,566	09/30/2003	Gordon Y. Li	81373818US01-02CXT0070D	9980

65913 7590 02/19/2009
NXP, B.V.
NXP INTELLECTUAL PROPERTY DEPARTMENT
M/S41-SJ
1109 MCKAY DRIVE
SAN JOSE, CA 95131

EXAMINER	
HOSSAIN, TANIM M	
ART UNIT	PAPER NUMBER
2445	
NOTIFICATION DATE	DELIVERY MODE
02/19/2009	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ip.department.us@nxp.com

Office Action Summary	Application No.	Applicant(s)	
	10/675,566	LI ET AL.	
	Examiner	Art Unit	
	Tanim Hossain	2445	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *30 September 2003*.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-15* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-15* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *30 September 2003* is/are: a)☒ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

Claims 1-15 are rejected under 35 U.S.C. 102(e) as being anticipated by Brooks (U.S. 2001/0039600)

The applied reference has a common assignee with the instant application. Based upon the earlier effective U.S. filing date of the reference, it constitutes prior art under 35 U.S.C. 102(e). This rejection under 35 U.S.C. 102(e) might be overcome either by a showing under 37 CFR 1.132 that any invention disclosed but not claimed in the reference was derived from the inventor of this application and is thus not the invention "by another," or by an appropriate showing under 37 CFR 1.131.

As per claim 1, Brooks teaches a cable modem system comprising: a data networking engine that performs data networking functions (Abstract; paragraphs 0013-0016); and a cable modem engine that performs all other cable modem functions (Abstract; paragraphs 0013-0016); the cable modem engine being completely partitioned from the data networking engine (Abstract; paragraphs 0013-0016).

As per claim 2, Brooks teaches a cable modem system as claimed in claim 1, wherein all DOCSIS functions are localized in the cable modem engine (0024-0026).

As per claim 3, Brooks teaches a cable modem system as claimed in claim 2, wherein VolP functionality is embedded in the cable modem engine (0024-0026).

As per claim 4, Brooks teaches a cable modem system as claimed in claim 1, and further comprising an advanced crypto engine that performs all crypto functions (0013).

As per claim 5, Brooks teaches a cable modem system as claimed in claim 1, wherein the cable modem engine comprises: a DOCSIS PHY layer (0024-0026); a DOCSIS MAC processor (0024-0026); and a DOCSIS controller (0024-0026).

As per claim 6, Brooks teaches a cable modem system as claimed in claim 5, wherein the DOCSIS PHY layer comprises a hardware transmitter and receiver (0024-0026).

As per claim 7, Brooks teaches a cable modem system as claimed in claim 5, wherein the DOCSIS MAC processor processes downstream PDU packets and forwards the processed packets directly to the data networking engine without the involvement of the DOCSIS controller in order to boost downstream throughput (0024-0026).

As per claim 8, Brooks teaches a cable modem system as claimed in claim 5, wherein all VoIP functionality is implemented in the DOCSIS controller (0024-0026).

As per claim 9, Brooks teaches a cable modem system as claimed in claim 8, wherein the VolP functionality is in conformance with the PacketCable specification (0024-0026).

As per claim 10, Brooks teaches a cable modem system as claimed in claim 5, wherein the data networking engine is responsible for all data networking processing including advanced

multi-port briding/routing with NAT/firewall and VPN, and home networking applications (0024-0026).

As per claim 11, Brooks teaches a cable modem system as claimed in claim 10, wherein the data networking engine comprises the entire embedded portal services functionality of the CableHome specification (0024-0026).

As per claim 12, Brooks teaches a cable modem architecture comprising: a cable modem engine comprising: a DOCSIS PHY layer comprising a transmitter and receiver (0024-0026); a DOCSIS MAC processor that implements real-time critical MAC functions for both upstream and downstream communications (0024-0026); and a DOCSIS controller implementing VolP functionality (0024-0026); and a data networking engine implementing all data networking processing and home networking applications, wherein the data networking engine is completely decoupled from the cable modem engine (0024-0026).

As per claim 13, Brooks teaches a cable modem architecture as claimed in claim 12, wherein the DOCSIS controller provides VolP functionality in accordance with the PacketCable specification, and wherein the data networking engine provides the embedded portal services functionality of the CableHome specification, wherein the CableHome functionality is provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine (0013-0016, 0024-0026).

As per claim 14, Brooks teaches a cable modem architecture as claimed in claim 13, wherein the DOCSIS MAC processor is an ARM9TDMI-based RISC processor, and wherein the DOCSIS controller is an ARM940-based RISC processor (0013-0016, 0024-0026).

As per claim 15, Brooks teaches a method for providing a flexible and partitioned cable modem gateway comprising: providing data and home networking functionality in a data networking engine; providing DOCSIS and VolP functionality in a cable modem engine (0013-0016, 0024-0026); and partitioning the data networking engine from the cable modem engine so that the data and home networking functionality is completely decoupled from the DOCSIS and VolP functionality (0013-0016, 0024-0026).

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Tanim Hossain whose telephone number is (571)272-3881. The examiner can normally be reached on 8:30 am - 5 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Glenton Burgess can be reached on 571/272-3949. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Tanim Hossain
Patent Examiner
Art Unit 2445
/Larry D Donaghue/
Primary Examiner, Art Unit 2454

Confirmation No. 9980

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	LI *et al.*	Examiner:	Hossain, Tanim
Serial No.:	10/675,566	Group Art Unit:	2445
Filed:	September 30, 2003	Docket No.:	81373818US01 (NXPS.615PA)
Title:	ARCHITECTURE FOR A FLEXIBLE AND HIGH-PERFORMANCE GATEWAY CABLE MODEM		

AMENDMENT AND RESPONSE TO OFFICE ACTION

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Customer No.
65913

Dear Sir:

In acknowledgement of the non-final Office Action dated February 19, 2009, please reconsider the application in view of the following amendments and remarks.

A complete listing of the claims, including any amendments, and Remarks/Arguments follow.

In the Claims:

Please amend the claims as indicated below.

1. (Currently Amended) A cable modem system comprising:

a data networking engine implemented in a first circuit that includes at least one processor, the data networking engine programmed with software that when executed by the at least one processor of the first circuit causes the data networking engine to perform ~~that performs~~ home ~~data~~ networking functions including interfacing with customer provided equipment; ~~and~~

a cable modem engine implemented in a second circuit that includes at least one processor, the second circuit being separate from the first circuit, the cable modem engine programmed with software that when executed by the at least one processor of the second circuit causes the cable mode engine to perform ~~that performs all other~~ cable modem functions other than the home networking functions performed by the data networking engine, the cable modem engine configured to enable upgrades to its software in a manner that is independent of upgrades to the software of the data networking engine; and

a data bus that connects the data networking engine to the cable modem engine,

wherein the cable modem functions performed by the cable modem engine are ~~being~~ completely partitioned from the home networking functions performed by the data networking engine.

2. (Original) A cable modem system as claimed in claim 1, wherein all DOCSIS functions are localized in the cable modem engine.

3. (Original) A cable modem system as claimed in claim 2, wherein VoIP functionality is embedded in the cable modem engine.

4. (Currently Amended) A cable modem system as claimed in claim 1, and further comprising an advanced crypto engine configured to perform ~~that performs~~ all crypto functions for both the data networking engine and the cable modem engine, the advanced crypto engine being separate from both the data networking engine and the cable modem

engine.

5. (Currently Amended) A cable modem system as claimed in claim 1, wherein the cable modem engine includes ~~comprises~~:

a DOCSIS PHY layer;

a DOCSIS MAC processor; and

a DOCSIS controller, and

wherein the at least one processor of the data networking engine is a RISC processor.

6. (Currently Amended) A cable modem system as claimed in claim 5, wherein the DOCSIS PHY layer includes ~~comprises~~ a hardware transmitter and receiver.

7. (Currently Amended) A cable modem system as claimed in claim 5, wherein the DOCSIS MAC processor is configured to process ~~processes~~ downstream PDU packets and forward ~~forwards~~ the processed packets directly to the data networking engine without the involvement of the DOCSIS controller in order to boost downstream throughput.

8. (Original) A cable modem system as claimed in claim 5, wherein all VoIP functionality is implemented in the DOCSIS controller.

9. (Original) A cable modem system as claimed in claim 8, wherein the VoIP functionality is in conformance with the PacketCable specification.

10. (Currently Amended) A cable modem system as claimed in claim 5, wherein the data networking engine is configured to perform ~~responsible for~~ all data networking processing including advanced multi-port bridging ~~briding~~/routing with NAT/firewall and VPN, and home networking applications.

11. (Original) A cable modem system as claimed in claim 10, wherein the data networking engine comprises the entire embedded portal services functionality of the CableHome specification.

12. (Currently Amended) A cable modem architecture comprising:

a cable modem engine <u>that includes</u> ~~comprises~~:

a DOCSIS PHY layer comprising a transmitter and receiver;

a DOCSIS MAC processor <u>configured to implement</u> ~~that implements~~ real-time critical MAC functions for both upstream and downstream communications; and

a DOCSIS controller <u>configured to implement</u> ~~implementing~~ VoIP functionality; and

a data networking engine <u>that includes a RISC processor configured to implement</u> ~~implementing~~ all data networking processing and home networking applications, wherein the <u>implementation of the data networking processing and home networking applications by</u> the data networking engine is completely decoupled from <u>the implementation of the MAC functions and the VoIP functionality by</u> the cable modem engine.

13. (Currently Amended) A cable modem architecture as claimed in claim 12, wherein the DOCSIS controller <u>is configured to provide</u> ~~provides~~ VoIP functionality in accordance with the PacketCable specification, ~~and~~ wherein the data networking engine <u>is configured to provide</u> ~~provides~~ the embedded portal services functionality of the CableHome specification, <u>and</u> wherein the CableHome functionality ~~is~~ provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine.

14. (Original) A cable modem architecture as claimed in claim 13, wherein the DOCSIS MAC processor is an ARM9TDMI-based RISC processor, and wherein the DOCSIS controller is an ARM940-based RISC processor.

15. (Original) A method for providing a flexible and partitioned cable modem gateway comprising: providing data and home networking functionality in a data networking engine; providing DOCSIS and VoIP functionality in a cable modem engine; and partitioning the data networking engine from the cable modem engine so that the data and home networking functionality is completely decoupled from the DOCSIS and VoIP functionality.

16. (New) A cable modem system as claimed in claim 5, wherein the data networking engine includes consumer provided equipment drivers including a USB driver and an Ethernet driver and the data networking engine is configured to provide the embedded portal services functionality of the CableHome specification, wherein the DOCSIS controller is configured to provide VoIP functionality in accordance with the PacketCable specification, and wherein the CableHome functionality provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine.

Remarks

In the non-final Office Action dated February 19, 2009, the following grounds of rejection are presented: claims 1-15 stand rejected under 35 U.S.C. § 102(e) over Brooks (U.S. Patent Pub. 2001/0039600). In the following discussion, Applicant does not acquiesce in any regard to averments in this Office Action (unless Applicant expressly indicates otherwise).

Applicant respectfully traverses the § 102(e) rejection of claims 1-15 because the cited portions of the '600 reference do not correspond to aspects of the claimed invention directed to the data networking functions performed by a data networking engine being completely partitioned/decoupled from the other cable modem functions performed by a cable modem engine. The cited portions of the '600 reference teach a cable modem device 100 that includes two separate processors 102 and 104 (*see, e.g.,* Figure 1 and paragraphs 0024-0026, which are apparently being asserted as corresponding to the DOCSIS MAC processor and the DOCSIS controller of Applicant's cable modem engine (*see, e.g.,* claims 5-14). Applicant submits that the '600 reference does not teach a separate data networking engine (as claimed) that implements certain functionality in a manner that is completely partitioned/decoupled from the functionality performed by processors 102 and 104 of cable modem device 100. Specifically, the '600 reference teaches that the home-networking functionality is implemented by the same processors that implement the DOCSIS and VoIP functionality, instead of implementing these functionalities in a partitioned manner in separate engines, as claimed. Thus, the cited portions of the '600 reference do not correspond to the claimed invention.

Applicant notes that the Office Action does not identify what element of the '600 reference is being asserted as corresponding to Applicant's data networking engine. In fact, the Office Action fails to provide any explanation regarding which specific elements of the '600 reference (*e.g.,* processors 102 and 104) are alleged to correspond to any element of the claimed invention (*e.g.,* Applicant's data networking engine, cable modem engine, DOCSIS MAC processor and the DOCSIS controller). In order to comply with 35 U.S.C. § 132, sufficient detail must be provided by the Examiner regarding the alleged correspondence between the claimed invention and the cited reference to enable Applicant to adequately respond to the rejections. *See, also,* 37 CFR 1.104 ("The pertinence of each reference, if not apparent, must be clearly explained and each rejected

claim specified.") and M.P.E.P. § 706.02(j), ("It is important for an Examiner to properly communicate the basis for a rejection so that the issues can be identified early and the applicant can be given fair opportunity to reply."). As such, should any rejection based on the '600 reference be maintained, Applicant respectfully requests that the Examiner specifically identify which element of the '600 reference is being alleged to correspond to each element of the claimed invention.

In view of the above, the § 102(e) rejection of claims 1-15 is improper and Applicant requests that it be withdrawn.

Applicant further traverses the § 102(e) rejection of various dependent claims because the Office Action fails to adequately address these claims. Regarding claim 7, the '600 reference does not teach that processor 102 (taught by the '600 reference to implement MAC functionality) processes PDU packets and forwards these packets to an apparently nonexistent data networking engine (as claimed) without the involvement of some other processor, which is not identified by the Office Action. Regarding claims 9, 11 and 13-14, the '600 reference does not teach that cable modem device 100 implements functionality of the PacketCable specification or functionality of the CableHome specification. In fact, the '600 reference does not make any mention of either the PacketCable specification or the CableHome specification. Accordingly, the § 102(e) rejection of claims 7, 9, 11 and 13-14 is improper and Applicant requests that it be withdrawn.

In view of the above, Applicant believes that each of the rejections is improper and should be withdrawn and that the application is in condition for allowance. Should there be any remaining issues that could be readily addressed over the telephone, the Examiner is asked to contact the agent overseeing the application file, David Cordeiro, of NXP Corporation at (408) 474-9063 (or the undersigned).

Please direct all correspondence to:

Corporate Patent Counsel
NXP Intellectual Property & Standards
1109 McKay Drive; Mail Stop SJ41
San Jose, CA 95131

CUSTOMER NO. 65913

By: ______________________
Name: Robert J. Crawford
Reg. No.: 32,122
651-686-6633
(NXPS.615PA)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/675,566	09/30/2003	Gordon Y. Li	81373818US01-02CXT0070D	9980

65913 7590 09/03/2009
NXP, B.V.
NXP INTELLECTUAL PROPERTY & LICENSING
M/S41-SJ
1109 MCKAY DRIVE
SAN JOSE, CA 95131

EXAMINER	
HOSSAIN, TANIM M	
ART UNIT	PAPER NUMBER
2445	

NOTIFICATION DATE	DELIVERY MODE
09/03/2009	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ip.department.us@nxp.com

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No.	Applicant(s)	
	10/675,566	LI ET AL.	
	Examiner	Art Unit	
	Tanim Hossain	2445	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 1 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 5/19/09.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-16 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☐ Claim(s) _____ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☒ Claim(s) 1-16 are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Election/Restrictions

Restriction to one of the following inventions is required under 35 U.S.C. 121:

I. Claims 1-11 and 16, drawn to computer software upgrading, classified in class 717, subclass 168.

II. Claims 12-15, drawn to network protocol implementation, classified in class 709, subclass 230.

Inventions I and II are related as subcombinations as usable together in a single combination. The subcombinations are distinct from each other if they are shown to be separately usable. In the instant case, Invention I discloses the upgrading of software for the system in an independent fashion. This specific upgrading concept is classified in class 717, subclass 168. On the other hand, Invention II includes the implementation and use of various protocols to employ different network functionalities, and is thus classified accordingly, in class 709, subclass 230. Both inventions may be implemented separately from one another.

Because these inventions are distinct for the reasons given above and have acquired a separate status in the art as shown by their different classifications, restriction for examination purposes as indicated is proper.

Applicant is advised that the reply to this requirement to be complete must include an election of the invention to be examined even though the requirement be traversed (37 CFR 1.143).

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Tanim Hossain whose telephone number is (571)272-3881. The examiner can normally be reached on 8:30 am - 5 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Vivek Srivastava can be reached on 571/272-7304. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Tanim Hossain
Patent Examiner
Art Unit 2445

/VIVEK SRIVASTAVA/

Supervisory Patent Examiner, Art Unit 2445

Confirmation No. 9980

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	LI *et al.*	Examiner:	Hossain, Tanim
Serial No.:	10/675,566	Group Art Unit:	2445
Filed:	September 30, 2003	Docket No.:	81373818US01 (NXPS.615PA)
Title:	ARCHITECTURE FOR A FLEXIBLE AND HIGH-PERFORMANCE GATEWAY CABLE MODEM		

RESPONSE TO ELECTION/RESTRICTION

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Customer No.
65913

Dear Sir:

This communication is in reply to the Office Action dated September 3, 2009 in which a restriction/election requirement was presented.

A complete listing of the Claims, to include any amendments thereto, and the Remarks follow.

In the Claims:

1. (Previously presented) A cable modem system comprising:

a data networking engine implemented in a first circuit that includes at least one processor, the data networking engine programmed with software that when executed by the at least one processor of the first circuit causes the data networking engine to perform home networking functions including interfacing with customer provided equipment;

a cable modem engine implemented in a second circuit that includes at least one processor, the second circuit being separate from the first circuit, the cable modem engine programmed with software that when executed by the at least one processor of the second circuit causes the cable mode engine to perform cable modem functions other than the home networking functions performed by the data networking engine, the cable modem engine configured to enable upgrades to its software in a manner that is independent of upgrades to the software of the data networking engine; and

a data bus that connects the data networking engine to the cable modem engine,

wherein the cable modem functions performed by the cable modem engine are completely partitioned from the home networking functions performed by the data networking engine.

2. (Original) A cable modem system as claimed in claim 1, wherein all DOCSIS functions are localized in the cable modem engine.

3. (Original) A cable modem system as claimed in claim 2, wherein VoIP functionality is embedded in the cable modem engine.

4. (Previously presented) A cable modem system as claimed in claim 1, and further comprising an advanced crypto engine configured to perform all crypto functions for both the data networking engine and the cable modem engine, the advanced crypto engine being separate from both the data networking engine and the cable modem engine.

5. (Previously presented) A cable modem system as claimed in claim 1, wherein the cable modem engine includes:

a DOCSIS PHY layer;

a DOCSIS MAC processor; and

a DOCSIS controller, and

wherein the at least one processor of the data networking engine is a RISC processor.

6. (Previously presented) A cable modem system as claimed in claim 5, wherein the DOCSIS PHY layer includes a hardware transmitter and receiver.

7. (Previously presented) A cable modem system as claimed in claim 5, wherein the DOCSIS MAC processor is configured to process downstream PDU packets and forward the processed packets directly to the data networking engine without the involvement of the DOCSIS controller in order to boost downstream throughput.

8. (Original) A cable modem system as claimed in claim 5, wherein all VoIP functionality is implemented in the DOCSIS controller.

9. (Original) A cable modem system as claimed in claim 8, wherein the VoIP functionality is in conformance with the PacketCable specification.

10. (Previously presented) A cable modem system as claimed in claim 5, wherein the data networking engine is configured to perform all data networking processing including advanced multi-port bridging routing with NAT/firewall and VPN, and home networking applications.

11. (Original) A cable modem system as claimed in claim 10, wherein the data networking engine comprises the entire embedded portal services functionality of the CableHome specification.

12. (Currently amended) A cable modem system as claimed in claim 5, wherein the ~~architecture~~ ~~comprising: a~~ cable modem engine ~~that~~ includes:

the [[a]] DOCSIS PHY layer includes ~~comprising~~ a transmitter and receiver;

the [[a]] DOCSIS MAC processor is configured to implement real-time ~~critical~~ MAC functions for both upstream and downstream communications; and

the [[a]] DOCSIS controller is configured to implement VoIP functionality; and wherein

the [[a]] data networking engine ~~that~~ includes a RISC processor configured to implement substantially all data networking processing and home networking applications~~, wherein the implementation of the data networking processing and home networking applications by the data networking engine is completely~~ decoupled from the implementation of the MAC functions and the VoIP functionality of ~~by~~ the cable modem engine.

13. (Previously presented) A cable modem architecture as claimed in claim 12, wherein the DOCSIS controller is configured to provide VoIP functionality in accordance with the PacketCable specification, wherein the data networking engine is configured to provide the embedded portal services functionality of the CableHome specification, and wherein the CableHome functionality provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine.

14. (Original) A cable modem architecture as claimed in claim 13, wherein the DOCSIS MAC processor is an ARM9TDMI-based RISC processor, and wherein the DOCSIS controller is an ARM940-based RISC processor.

15. (Original) A method for providing a flexible and partitioned cable modem gateway comprising: providing data and home networking functionality in a data networking engine; providing DOCSIS and VoIP functionality in a cable modem engine; and partitioning the data networking engine from the cable modem engine so that the data and home networking functionality is completely decoupled from the DOCSIS and VoIP functionality.

16. (Previously presented) A cable modem system as claimed in claim 5, wherein the data networking engine includes consumer provided equipment drivers including a USB driver and an Ethernet driver and the data networking engine is configured to provide the embedded portal services functionality of the CableHome specification, wherein the DOCSIS controller is configured to provide VoIP functionality in accordance with the PacketCable specification, and wherein the CableHome functionality provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine.

Remarks

In the Office Action dated September 3, 2009, a Restriction/Election was made, requesting that Applicant elect either Group I (consisting of claims 1-11 and 16) or Group II (consisting of claims 12-15). Applicant elects the claims identified under Group I (claims 1-11, 12-14 as amended and 16) with traverse. Applicant respectfully submits that the rationale used in support of the restrictions does not comply with the rules and guidelines set forth in the M.P.E.P. Applicant submits that the restrictions should be withdrawn.

The Office Action asserts that the inventions of Groups I and II are related as subcombinations as usable together in a single combination and that both inventions may be implemented separately from one another. Specifically, the Office Action asserts that the invention of Group I "discloses the upgrading of software for the system in an independent fashion" and the invention of Group II "includes the implementation and use of various protocols to employ different network functionalities."

Applicant traverses for lack of compliance with the restriction guidelines in the M.P.E.P. and because no basis has been provided to support the separate use conclusion in the Office Action.

Notwithstanding, Applicant has amended claim 12 to comport to the scope presented in the Office Action.

Accordingly, Applicants respectfully requests that the Examiner withdraw the present restriction requirement(s) for examination of all the claims.

In view of the above, Applicant believes that each of the rejections is improper and should be withdrawn and that the application is in condition for allowance. Should there be any remaining issues that could be readily addressed over the telephone, the Examiner is asked to contact the agent overseeing the application file, Peter Zawilski, of NXP Corporation at (408) 474-9063 (or the undersigned).

Please direct all correspondence to:

Corporate Patent Counsel
NXP Intellectual Property & Standards
1109 McKay Drive; Mail Stop SJ41
San Jose, CA 95131

CUSTOMER NO. 65913

By: ______________________
Name: Robert J. Crawford
Reg. No.: 32,122
651-686-6633
(NXPS.615PA)

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/675,566	09/30/2003	Gordon Y. Li	81373818US01-02CXT0070D	9980

65913 7590 02/05/2010

NXP, B.V.
NXP INTELLECTUAL PROPERTY & LICENSING
M/S41-SJ
1109 MCKAY DRIVE
SAN JOSE, CA 95131

EXAMINER	
HOSSAIN, TANIM M	
ART UNIT	PAPER NUMBER
2445	

NOTIFICATION DATE	DELIVERY MODE
02/05/2010	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

ip.department.us@nxp.com

Office Action Summary	Application No. 10/675,566	Applicant(s) LI ET AL.	
	Examiner Tanim Hossain	Art Unit 2445	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *05 October 2009*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-16* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-16* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Claim Objections

Claim 1 is objected to because of the following informalities: The term, "the cable mode engine" in line 9 appears to be a typographical error. Appropriate correction is required.

Election/Restriction

The restriction requirement filed on September 3, 2009 is hereby withdrawn.

Claim Rejections - 35 USC § 112

The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

Claim 12 is rejected under 35 U.S.C. 112, first paragraph, as failing to comply with the written description requirement. The claim(s) contains subject matter which was not described in the specification in such a way as to reasonably convey to one skilled in the relevant art that the inventor(s), at the time the application was filed, had possession of the claimed invention. Claim 12 discloses that the data networking engine includes a RISC processor, which is not supported by the specification.

The following is a quotation of the second paragraph of 35 U.S.C. 112:

> The specification shall conclude with one or more claims particularly pointing out and distinctly claiming the subject matter which the applicant regards as his invention.

Claims 12 -14 are rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention.

Claim 12 contains the term “substantially” The term is not defined in the specification rendering the claim indefinite. Other claims are dependent from claim 12.

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (e) the invention was described in (1) an application for patent, published under section 122(b), by another filed in the United States before the invention by the applicant for patent or (2) a patent granted on an application for patent by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in section 351(a) shall have the effects for purposes of this subsection of an application filed in the United States only if the international application designated the United States and was published under Article 21(2) of such treaty in the English language.

Claims 1-16 are rejected under 35 U.S.C. 102(e) as being anticipated by Brooks (U.S. 2001/0039600).

The applied reference has a common assignee with the instant application. Based upon the earlier effective U.S. filing date of the reference, it constitutes prior art under 35 U.S.C. 102(e). This rejection under 35 U.S.C. 102(e) might be overcome either by a showing under 37 CFR 1.132 that any invention disclosed but not claimed in the reference was derived from the inventor of this application and is thus not the invention “by another,” or by an appropriate showing under 37 CFR 1.131.

As per claim 1, Brooks teaches a cable modem system comprising: a data networking engine implemented in a first circuit that includes at least one processor (Figure 2), the data networking engine programmed with software that when executed by the at least one processor of the first circuit causes the data networking engine to perform home networking functions including interfacing with customer provided equipment (Abstract; paragraphs 0014, 0026, 0037, 0066-0068); a cable modem engine implemented in a second circuit that includes at least one processor, the second circuit being separate from the first circuit, the cable modem engine programmed with software that when executed by the at least one processor of the second circuit causes the cable modem engine to perform cable modem functions other than the home networking functions performed by the data networking engine, the cable modem engine configured to enable upgrades to its software in a manner that is independent of upgrades to the software of the data networking engine (paragraphs 0026, 0037, 0042-0046, 0050-0052); a data bus that connects the data networking engine to the cable modem engine, wherein the cable modem functions performed by the cable modem engine are completely partitioned from the home networking functions performed by the data networking engine (0042-0046).

As per claim 2, Brooks teaches a cable modem system as claimed in claim 1, wherein all DOCSIS functions are localized in the cable modem engine (0024-0026).

As per claim 3, Brooks teaches a cable modem system as claimed in claim 2, wherein VoIP functionality is embedded in the cable modem engine (0024-0026).

As per claim 4, Brooks teaches a cable modem system as claimed in claim 1, and further comprising an advanced crypto engine that performs all crypto functions (0013).

As per claim 5, Brooks teaches a cable modem system as claimed in claim 1, wherein the cable modem engine comprises: a DOCSIS PHY layer (0024-0026); a DOCSIS MAC processor (0024-0026); and a DOCSIS controller (0024-0026).

As per claim 6, Brooks teaches a cable modem system as claimed in claim 5, wherein the DOCSIS PHY layer comprises a hardware transmitter and receiver (0013, 0024-0026).

As per claim 7, Brooks teaches a cable modem system as claimed in claim 5, wherein the DOCSIS MAC processor processes downstream PDU packets and forwards the processed packets directly to the data networking engine without the involvement of the DOCSIS controller in order to boost downstream throughput (0024-0026, 0028).

As per claim 8, Brooks teaches a cable modem system as claimed in claim 5, wherein all VoIP functionality is implemented in the DOCSIS controller (0024-0026).

As per claim 9, Brooks teaches a cable modem system as claimed in claim 8, wherein the VoIP functionality is in conformance with the PacketCable specification (0024-0026).

As per claim 10, Brooks teaches a cable modem system as claimed in claim 5, wherein the data networking engine is responsible for all data networking processing including advanced

multi-port bridging/routing with NAT/firewall and VPN, and home networking applications (0024-0026, 0030).

As per claim 11, Brooks teaches a cable modem system as claimed in claim 10, wherein the data networking engine comprises the entire embedded portal services functionality of the CableHome specification (0024-0026).

As per claim 12, Brooks teaches a cable modem as claimed in claim 5, wherein the cable modem engine includes: the DOCSIS PHY layer includes a transmitter and receiver (0030); the DOCSIS MAC processor is configured to implement real-time MAC functions for both upstream and downstream communications (0053-0054); the DOCSIS controller is configured to implement VoIP functionality (0025); and wherein the data networking engine includes a RISC processor configured to implement all data networking processing and home networking applications, decoupled from the implementation of the MAC functions and the VoIP functionality of the cable modem engine (0037, 0043-0045).

As per claim 13, Brooks teaches a cable modem architecture as claimed in claim 12, wherein the DOCSIS controller provides VoIP functionality in accordance with the PacketCable specification, and wherein the data networking engine provides the embedded portal services functionality of the CableHome specification, wherein the CableHome functionality provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine (0013-0016, 0024-0026).

As per claim 14, Brooks teaches a cable modem architecture as claimed in claim 13, wherein the DOCSIS MAC processor is an ARM9TDMI-based RISC processor, and wherein the DOCSIS controller is an ARM940-based RISC processor (0013-0016, 0024-0026, 0037).

As per claim 15, Brooks teaches a method for providing a flexible and partitioned cable modem gateway comprising: providing data and home networking functionality in a data networking engine; providing DOCSIS and VoIP functionality in a cable modem engine (0013-0016, 0024-0026); and partitioning the data networking engine from the cable modem engine so that the data and home networking functionality is completely decoupled from the DOCSIS and VoIP functionality (0013-0016, 0024-0026).

As per claim 16, Brooks teaches a cable modem system as claimed in claim 5, wherein the data networking engine includes consumer provided equipment drivers including a USB driver and an Ethernet driver and the data networking engine is configured to provide the embedded portal services functionality of the CableHome specification, wherein the DOCSIS controller is configured to provide VoIP functionality in accordance with the PacketCable specification, and wherein the CableHome functionality provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine (0044-0045).

Response to Remarks

Applicant's remarks filed on May 19, 2009 have fully been considered.

The data networking engine and cable modem engines are represented in figures 1 and 2 of the Brooks reference, including buses carrying out separate networking functions. For example, the data networking engine interfaces with the peripheral devices and employs operating system functions, and the cable modem engine implements DOCSIS functionality. These entities are completely partitioned from each other, as discussed in the cited sections.

Paragraphs 0036-0042 discuss the transfer of packets between the cable modem and data networking engines. Therefore, examiner respectfully disagrees with the assertion that there is no data networking engine, and it is respectfully submitted that the Brooks invention fully teaches the limitations of claim 7. Further, paragraph 0010 discusses the inclusion of various CableLabs standards. Because PacketCable and CableHome specifications constitute these standards, Brooks fully teaches the claim limitations.

Conclusion

THIS ACTION IS MADE FINAL. Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Tanim Hossain whose telephone number is (571)272-3881. The examiner can normally be reached on 8:30 am - 5 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Vivek Srivastava can be reached on 571/272-7304. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

Tanim Hossain
Patent Examiner
Art Unit 2445

/Nabil El-Hady/
Supervisory Patent Examiner, Art Unit 4191

Reply under 37 C.F.R. 1.116
Expedited Procedure
Technology Center 2445

Confirmation No. 9980

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	LI *et al.*	Examiner:	Hossain, Tanim
Serial No.:	10/675,566	Group Art Unit:	2445
Filed:	September 30, 2003	Docket No.:	81373818US01 (NXPS.615PA)
Title:	ARCHITECTURE FOR A FLEXIBLE AND HIGH-PERFORMANCE GATEWAY CABLE MODEM		

REQUEST TO WITHDRAW FINALITY AND RESPONSE TO FINAL OFFICE ACTION

Mail Stop AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Customer No. 65913

Dear Sir:

In acknowledgement of the Final Office Action dated February 5, 2010, please reconsider the application in view of the following amendments and remarks.

A complete listing of the claims, including any amendments, and Remarks/Arguments follow.

Authorization is given to charge/credit **Deposit Account 50-4019 (81373818US01)** all required fees/overages to enter this paper.

In the Claims:

1. (Currently amended) A cable modem system comprising:

a data networking engine implemented in a first circuit that includes at least one processor, the data networking engine programmed with software that when executed by the at least one processor of the first circuit causes the data networking engine to perform home networking functions including interfacing with customer provided equipment;

a cable modem engine implemented in a second circuit that includes at least one processor, the second circuit being separate from the first circuit, the cable modem engine programmed with software that when executed by the at least one processor of the second circuit causes the cable modem ~~mode~~ engine to perform cable modem functions other than the home networking functions performed by the data networking engine, the cable modem engine configured to enable upgrades to its software in a manner that is independent of upgrades to the software of the data networking engine; and

a data bus that connects the data networking engine to the cable modem engine,

wherein the cable modem functions performed by the cable modem engine are completely partitioned from the home networking functions performed by the data networking engine.

2. (Original) A cable modem system as claimed in claim 1, wherein all DOCSIS functions are localized in the cable modem engine.

3. (Original) A cable modem system as claimed in claim 2, wherein VoIP functionality is embedded in the cable modem engine.

4. (Previously presented) A cable modem system as claimed in claim 1, and further comprising an advanced crypto engine configured to perform all crypto functions for both the data networking engine and the cable modem engine, the advanced crypto engine being separate from both the data networking engine and the cable modem engine.

5. (Previously presented) A cable modem system as claimed in claim 1, wherein the cable modem engine includes:

a DOCSIS PHY layer;

a DOCSIS MAC processor; and

a DOCSIS controller, and

wherein the at least one processor of the data networking engine is a RISC processor.

6. (Previously presented) A cable modem system as claimed in claim 5, wherein the DOCSIS PHY layer includes a hardware transmitter and receiver.

7. (Previously presented) A cable modem system as claimed in claim 5, wherein the DOCSIS MAC processor is configured to process downstream PDU packets and forward the processed packets directly to the data networking engine without the involvement of the DOCSIS controller in order to boost downstream throughput.

8. (Original) A cable modem system as claimed in claim 5, wherein all VoIP functionality is implemented in the DOCSIS controller.

9. (Original) A cable modem system as claimed in claim 8, wherein the VoIP functionality is in conformance with the PacketCable specification.

10. (Previously presented) A cable modem system as claimed in claim 5, wherein the data networking engine is configured to perform all data networking processing including advanced multi-port bridging routing with NAT/firewall and VPN, and home networking applications.

11. (Original) A cable modem system as claimed in claim 10, wherein the data networking engine comprises the entire embedded portal services functionality of the CableHome specification.

12. (Currently Amended) A cable modem system as claimed in claim 5, wherein the cable modem engine includes:

the DOCSIS PHY layer includes a transmitter and receiver;

the DOCSIS MAC processor is configured to implement real-time MAC functions for both upstream and downstream communications; and

the DOCSIS controller is configured to implement VoIP functionality; and wherein

the data networking engine ~~that~~ includes a RISC processor configured to implement ~~substantially all~~ a majority of data networking processing and home networking applications decoupled from the implementation of the MAC functions and the VoIP functionality of the cable modem engine.

13. (Previously presented) A cable modem architecture as claimed in claim 12, wherein the DOCSIS controller is configured to provide VoIP functionality in accordance with the PacketCable specification, wherein the data networking engine is configured to provide the embedded portal services functionality of the CableHome specification, and wherein the CableHome functionality provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine.

14. (Original) A cable modem architecture as claimed in claim 13, wherein the DOCSIS MAC processor is an ARM9TDMI-based RISC processor, and wherein the DOCSIS controller is an ARM940-based RISC processor.

15. (Original) A method for providing a flexible and partitioned cable modem gateway comprising: providing data and home networking functionality in a data networking engine; providing DOCSIS and VoIP functionality in a cable modem engine; and partitioning the data networking engine from the cable modem engine so that the data and home networking functionality is completely decoupled from the DOCSIS and VoIP functionality.

16. (Previously presented) A cable modem system as claimed in claim 5, wherein the data networking engine includes consumer provided equipment drivers including a USB driver and an Ethernet driver and the data networking engine is configured to provide the embedded portal services functionality of the CableHome specification, wherein the DOCSIS controller is configured to provide VoIP functionality in accordance with the PacketCable specification, and wherein the CableHome functionality provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine.

Remarks

In the non-final Office Action dated February 5, 2010, the following grounds of rejection are presented: claim 1 is objected to as to informalities; claim 12 is rejected under 35 U.S.C § 112, first paragraph as failing to comply with the written description requirement; claims 12-14 are rejected under 35 U.S.C § 112, second paragraph as being indefinite; claims 1-16 stand rejected under 35 U.S.C. § 102(e) over Brooks (U.S. Patent Pub. 2001/0039600). In the following discussion, Applicant does not acquiesce in any regard to averments in this Office Action (unless Applicant expressly indicates otherwise).

Applicant has amended claim 1 to correct a typographical error, and requests that the objection be removed.

Applicant respectfully traverses the § 102(e) rejection of claims 1-16 because the cited portions of the '600 reference do not correspond to aspects of the claimed invention. For example, Applicant is uncertain how the '600 reference discloses aspects of the claimed invention directed to data networking functions performed by a data networking engine being completely partitioned/decoupled from the other cable modem functions performed by a cable modem engine. The Examiner has repeatedly failed to identify elements of the '600 reference corresponding to these aspects as requested. In contrast, the Office Action make the conclusion statement that "the data networking engine and cable modem engines are represented in Figures 1 and 2 of the ['600] reference" (*see, e.g.*, p. 8 of the Office Action). However, Applicant is uncertain how any reasonable interpretation of these Figures can provide correspondence. For example, Figure 2 of the '600 reference discloses only two processors, each of which, therefore, must correspond to the claimed data-networking and cable-modem engines. However, the discussion of Figure 2 makes clear that the cable modem functions are performed by CMAC unit 224 (*see, e.g.*, paragraph 0042). Therefore, in order for the cable modem engine to contain a processor and perform the CMAC functions as claimed, the cited cable modem engine must include circuitry to connect the processors with the CMAC unit. Because available connecting circuitry would be shared with the other processor, Applicant is uncertain how the asserted cable modem engine and home networking engine can be completely

partitioned as claimed. Because the Office Action has not identified these claimed aspects in the '600 reference, a *prima facie* case has not been presented and Applicant requests that the rejection of claims 1-16 be withdrawn.

Applicant submits that the Examiner's failure to identify corresponding elements as requested in Applicant's response constitutes an incomplete answer under M.P.E.P. § 707.07 and, therefore, makes the finality of the Office Action improper. In order to comply with 35 U.S.C. § 132, sufficient detail must be provided by the Examiner regarding the alleged correspondence between the claimed invention and the cited reference to enable Applicant to adequately respond to the rejections. *See, also,* 37 CFR 1.104 ("The pertinence of each reference, if not apparent, must be clearly explained and each rejected claim specified.") and M.P.E.P. § 706.02(j), ("It is important for an Examiner to properly communicate the basis for a rejection so that the issues can be identified early and the applicant can be given fair opportunity to reply."). Because the Examiner has repeatedly failed to identify specific elements of the '600 reference which provide correspondence (as requested in the previous response), Applicant submits that the Office Action is unresponsive to Applicant's arguments and Applicant requests the finality of the Office Action be withdrawn.

Applicant respectfully traverses the § 112(1) rejection of claim 12 because aspects of the claim directed to a RISC processor are fully supported by Applicant's specification in compliance with the written description requirement. As shown in Figure 1 and related discussion at paragraph 0028 of Applicant's published specification, "the functions of the cable modem and data networking are rationally distributed among three different processors: DOCSIS MAC processor 114 (ARM #2); DOCSIS controller 116 (ARM #1); and data networking engine 120 (ARM #3)." Applicant submits that ARM, as commonly used in the art, refers to the Advanced RISC Machine (ARM). ARM is a 32-bit reduced instruction set computer (RISC) instruction set architecture developed by ARM Holding. Applicant submits that word-for-word correspondence is not required by the M.P.E.P. or relevant law, and maintains that the figures, together with the aforementioned discussion in the specification, fully support the claim limitations. *See, e.g., Union Oil Co. of California v. Atlantic Richfield Co.*, 208 F.3d 989 (Fed. Cir. 2000), *cert. denied*, 69 U.S.L.W. 3165 (Feb. 20, 2001) (No. 00-249) (quoting *In re Gosteli*, 872

F.2d 1008, 1012, 10 U.S.P.Q.2d 1614, 1618 (Fed. Cir. 1989) ("The written description requirement does not require the applicant "to describe exactly the subject matter claimed, [instead] the description must clearly allow persons of ordinary skill in the art to recognize that [he or she] invented what is claimed. "). Accordingly the 112(1) rejection is improper and should be withdrawn.

Applicant respectfully traverses the § 112(2) rejection of claims 12-14. While the Office Action erroneously suggests that "substantially" must be defined in the specification. Consistent with § 112(2), Applicant submits that, as used, the phase "substantially all" would be understood by one of ordinary skill in the art in light of the specification and in the context of decoupling performance of data networking and home networking applications from the implementation of the MAC and VoIP functionality. *See, Andrew Corp. v. Gabriel Electronics*, 847 F.2d 819 (Fed. Cir. 1988). Accordingly, the §112(2) rejection of claims 12-14 fails. Notwithstanding the above, Applicant has amended the claims for clarity and to better reflect the original intent of the claims. The §112(2) rejection is believe to no longer apply.

In view of the above, Applicant believes that each of the rejections is improper and should be withdrawn and that the application is in condition for allowance. Should there be any remaining issues that could be readily addressed over the telephone, the Examiner is asked to contact the agent overseeing the application file, Peter Zawilski, of NXP Corporation at (408) 474-9063 (or the undersigned).

Please direct all correspondence to:

Corporate Patent Counsel
NXP Intellectual Property & Standards
1109 McKay Drive; Mail Stop SJ41
San Jose, CA 95131

CUSTOMER NO. 65913

By: ____________________
Name: Robert J. Crawford
Reg. No.: 32,122
651-686-6633
(NXPS.615PA)

Attorney Docket No.: 348162-982350

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicants: G. Li

Serial No: 10/675,566

Filed: September 30, 2003

Title: Architecture For A Flexible And High-Performance Gateway Cable Modem

Docket No.: 348162-982350

Customer No.: 94518

Certificate of Transmission Under 37 CFR 1.8

I hereby certify that this correspondence is being transmitted via electronic submission, Commissioner for Patents, Alexandria, VA 22313-1450 on:

April 5, 2010	/Susan Pingue/
Date	*Susan Pingue*

***

COMMUNICATION

Assistant Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313

Sir:

Attached herewith are copies of the Power of Attorney Form (SB/80) and Statement Under 37 CFR 3.73(b) (SB/96) signed by David L. Teichmann, Secretary and Director of Trident Microsystems (Far East) Ltd. in connection with the above-referenced US patent application.

Please note that the new Attorney Docket Number is 348162-982350.

The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. 07-1896 referencing our Docket No. 348162-982350.

Respectfully submitted,

DLA PIPER LLP US

Dated: April 5, 2010

By /David L. Alberti/
David L. Alberti
Reg. No. 43,465
Attorney for Applicants

DLA Piper LLP US
2000 University Avenue
East Palo Alto, CA 94303
Telephone: (650) 833-2052
Facsimile : (650) 833-2001

CUSTOMER NO. 94518

/SCP

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/675,566	09/30/2003	Gordon Y. Li	81373818US01-02CXT0070D	9980

94518 7590 05/11/2010
DLA PIPER LLP (US)
2000 UNIVERSITY AVENUE
EAST PALO ALTO, CA 94303

EXAMINER	
HOSSAIN, TANIM M	
ART UNIT	**PAPER NUMBER**
2445	

MAIL DATE	DELIVERY MODE
05/11/2010	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Advisory Action Before the Filing of an Appeal Brief	Application No.	Applicant(s)	
	10/675,566	LI ET AL.	
	Examiner	**Art Unit**	
	Tanim Hossain	2445	

--The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

THE REPLY FILED 05 April 2010 FAILS TO PLACE THIS APPLICATION IN CONDITION FOR ALLOWANCE.

1. ☒ The reply was filed after a final rejection, but prior to or on the same day as filing a Notice of Appeal. To avoid abandonment of this application, applicant must timely file one of the following replies: (1) an amendment, affidavit, or other evidence, which places the application in condition for allowance; (2) a Notice of Appeal (with appeal fee) in compliance with 37 CFR 41.31; or (3) a Request for Continued Examination (RCE) in compliance with 37 CFR 1.114. The reply must be filed within one of the following time periods:
   a) ☐ The period for reply expires ______months from the mailing date of the final rejection.
   b) ☒ The period for reply expires on: (1) the mailing date of this Advisory Action, or (2) the date set forth in the final rejection, whichever is later. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of the final rejection.
   Examiner Note: If box 1 is checked, check either box (a) or (b). ONLY CHECK BOX (b) WHEN THE FIRST REPLY WAS FILED WITHIN TWO MONTHS OF THE FINAL REJECTION. See MPEP 706.07(f).

Extensions of time may be obtained under 37 CFR 1.136(a). The date on which the petition under 37 CFR 1.136(a) and the appropriate extension fee have been filed is the date for purposes of determining the period of extension and the corresponding amount of the fee. The appropriate extension fee under 37 CFR 1.17(a) is calculated from: (1) the expiration date of the shortened statutory period for reply originally set in the final Office action; or (2) as set forth in (b) above, if checked. Any reply received by the Office later than three months after the mailing date of the final rejection, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

NOTICE OF APPEAL

2. ☐ The Notice of Appeal was filed on _____. A brief in compliance with 37 CFR 41.37 must be filed within two months of the date of filing the Notice of Appeal (37 CFR 41.37(a)), or any extension thereof (37 CFR 41.37(e)), to avoid dismissal of the appeal. Since a Notice of Appeal has been filed, any reply must be filed within the time period set forth in 37 CFR 41.37(a).

AMENDMENTS

3. ☐ The proposed amendment(s) filed after a final rejection, but prior to the date of filing a brief, will not be entered because
   (a) ☐ They raise new issues that would require further consideration and/or search (see NOTE below);
   (b) ☐ They raise the issue of new matter (see NOTE below);
   (c) ☐ They are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal; and/or
   (d) ☐ They present additional claims without canceling a corresponding number of finally rejected claims.
   NOTE: _____. (See 37 CFR 1.116 and 41.33(a)).
4. ☐ The amendments are not in compliance with 37 CFR 1.121. See attached Notice of Non-Compliant Amendment (PTOL-324).
5. ☐ Applicant's reply has overcome the following rejection(s): _____.
6. ☐ Newly proposed or amended claim(s) _____ would be allowable if submitted in a separate, timely filed amendment canceling the non-allowable claim(s).
7. ☒ For purposes of appeal, the proposed amendment(s): a) ☐ will not be entered, or b) ☒ will be entered and an explanation of how the new or amended claims would be rejected is provided below or appended.
   The status of the claim(s) is (or will be) as follows:
   Claim(s) allowed: _____.
   Claim(s) objected to: _____.
   Claim(s) rejected: *1-16*.
   Claim(s) withdrawn from consideration: _____.

AFFIDAVIT OR OTHER EVIDENCE

8. ☐ The affidavit or other evidence filed after a final action, but before or on the date of filing a Notice of Appeal will not be entered because applicant failed to provide a showing of good and sufficient reasons why the affidavit or other evidence is necessary and was not earlier presented. See 37 CFR 1.116(e).
9. ☐ The affidavit or other evidence filed after the date of filing a Notice of Appeal, but prior to the date of filing a brief, will not be entered because the affidavit or other evidence failed to overcome all rejections under appeal and/or appellant fails to provide a showing a good and sufficient reasons why it is necessary and was not earlier presented. See 37 CFR 41.33(d)(1).
10. ☐ The affidavit or other evidence is entered. An explanation of the status of the claims after entry is below or attached.

REQUEST FOR RECONSIDERATION/OTHER

11. ☒ The request for reconsideration has been considered but does NOT place the application in condition for allowance because: See Continuation Sheet.
12. ☐ Note the attached Information *Disclosure Statement*(s). (PTO/SB/08) Paper No(s). _____
13. ☐ Other: _____.

/VIVEK SRIVASTAVA/
Supervisory Patent Examiner, Art Unit 2445

Continuation of 11. does NOT place the application in condition for allowance because: Brooks' abstract, for example, discloses bifurcated processing architecture. The first processor processes information flowing to and from cable media interface circuitry. This constitutes the data networking engine, which performs the interacting with equipment, as claimed. The second processor performs the management of some message processing and scheduling, which constitutes cable modem functions other than those of the data networking engine (please see paragraph 0026). This then constitutes the cable modem engine, as claimed. Claim 9 of the Brooks reference further teaches partitioned processors, where the co-processor supports the processing of cable media and performs data transfer, and the first processor performs a plurality of other processing functions.

The 112 rejections are hereby withdrawn.

Finality of the previous office action is proper, given that the cited paragraphs point to the birfurcated nature of the cable modem, where each of the processors perform different functions. This is sufficient to equate the corresponding processor to the data networking engine (the processor that handles the data flow), and the other to the cable modem engine (the processor that performs other functions).

Reply under 37 C.F.R. 1.116
Expedited Procedure
Technology Center 2445

Confirmation No. 9980

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	LI *et al.*	Examiner:	Hossain, Tanim
Serial No.:	10/675,566	Group Art Unit:	2445
Filed:	September 30, 2003	Docket No.:	81373818US01 (NXPS.615PA)
Title:	ARCHITECTURE FOR A FLEXIBLE AND HIGH-PERFORMANCE GATEWAY CABLE MODEM		

REQUEST TO WITHDRAW FINALITY AND RESPONSE TO FINAL OFFICE ACTION

Mail Stop AF
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Customer No. 65913

Okay to enter amendments.
Thanks, TH

Dear Sir:

In acknowledgement of the Final Office Action dated February 5, 2010, please reconsider the application in view of the following amendments and remarks.

A complete listing of the claims, including any amendments, and Remarks/Arguments follow.

Authorization is given to charge/credit **Deposit Account 50-4019 (81373818US01)** all required fees/overages to enter this paper.

PTO/SB/30 (09-08)
Approved for use through 10/31/2008. OMB 0651-0031
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it contains a valid OMB control number.

Request for Continued Examination (RCE) Transmittal

Address to:
Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Application Number	10/675,566
Filing Date	September 30, 2003
First Named Inventor	Gordon Y. Li
Art Unit	2445
Examiner Name	Tanim M. Hossain
Attorney Docket Number	348162-982350 [81373818US01]

This is a Request for Continued Examination (RCE) under 37 CFR 1.114 of the above-identified application.
Request for Continued Examination (RCE) practice under 37 CFR 1.114 does not apply to any utility or plant application filed prior to June 8, 1995, or to any design application. See Instruction Sheet for RCEs (not to be submitted to the USPTO) on page 2.

1. **Submission required under 37 CFR 1.114** Note: If the RCE is proper, any previously filed unentered amendments and amendments enclosed with the RCE will be entered in the order in which they were filed unless applicant instructs otherwise. If applicant does not wish to have any previously filed unentered amendment(s) entered, applicant must request non-entry of such amendment(s).

   a. ☐ Previously submitted. If a final Office action is outstanding, any amendments filed after the final Office action may be considered as a submission even if this box is not checked.

      i. ☐ Consider the arguments in the Appeal Brief or Reply Brief previously filed on ________

      ii. ☐ Other ________

   b. ☑ Enclosed

      i. ☑ Amendment/Reply
      ii. ☐ Affidavit(s)/ Declaration(s)
      iii. ☐ Information Disclosure Statement (IDS)
      iv. ☐ Other ________

2. **Miscellaneous**

   a. ☐ Suspension of action on the above-identified application is requested under 37 CFR 1.103(c) for a period of ________ months. (Period of suspension shall not exceed 3 months; Fee under 37 CFR 1.17(i) required)

   b. ☐ Other ________

3. **Fees** The RCE fee under 37 CFR 1.17(e) is required by 37 CFR 1.114 when the RCE is filed.

   a. ☑ The Director is hereby authorized to charge the following fees, any underpayment of fees, or credit any overpayments, to Deposit Account No. 07-1896.

      i. ☑ RCE fee required under 37 CFR 1.17(e)
      ii. ☑ Extension of time fee (37 CFR 1.136 and 1.17)
      iii. ☐ Other ________

   b. ☐ Check in the amount of $ ________ enclosed

   c. ☐ Payment by credit card (Form PTO-2038 enclosed)

WARNING: Information on this form may become public. Credit card information should not be included on this form. Provide credit card information and authorization on PTO-2038.

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT REQUIRED

Signature	/Gerald T. Sekimura/	Date	June 7, 2010
Name (Print/Type)	Gerald T. Sekimura	Registration No.	30,103

CERTIFICATE OF MAILING OR ELECTRONIC TRANSMISSION

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as first class mail in an envelope addressed to: Mail Stop RCE, Commissioner for Patents, P. O. Box 1450, Alexandria, VA 22313-1450 or electronically transmitted to the U.S. Patent and Trademark Office on the date shown below.

Signature	/Ta-Tanisha L. Henry/		
Name (Print/Type)	Ta-Tanisha L. Henry	Date	June 7, 2010

Appl. No.	:	10/675,566	Confirmation No.	9980
Applicants	:	Gordon Y. Li, et al.		
Filed	:	September 30, 2003		
TC/A.U.	:	2445		
Examiner	:	Tanim M. Hossain		
Docket No.	:	348162-982350 [81373818US01]		
Customer No.	:	94518		

Mail Stop RCE
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

AMENDMENT

Sir:

In connection with the Request for Continued Examination, filed herewith, please amend the subject application as follows:

Any Amendments to the Claims are reflected in the listing of claims which begins on page **2** of this paper.

Remarks/Arguments begin on page 6 of this paper.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

1. (Currently amended) A cable modem system comprising:

a data networking engine implemented in a first circuit that includes at least one processor, the data networking engine programmed with software that when executed by the at least one processor of the first circuit causes the data networking engine to perform home networking functions including interfacing with customer provided equipment;

a cable modem engine implemented in a second circuit that includes at least one processor, the second circuit being separate from the first circuit, the cable modem engine programmed with software that when executed by the at least one processor of the second circuit causes the cable modem engine to perform cable modem functions other than the home networking functions performed by the data networking engine, the cable modem functions including interfacing with cable media, and the cable modem engine configured to enable upgrades to its software in a manner that is independent of upgrades to the software of the data networking engine; and

a data bus that connects the data networking engine to the cable modem engine,

wherein the cable modem functions performed by the cable modem engine are completely partitioned from the home networking functions performed by the data networking engine.

2. (Original) A cable modem system as claimed in claim 1, wherein all DOCSIS functions are localized in the cable modem engine.

3. (Original) A cable modem system as claimed in claim 2, wherein VoIP functionality is embedded in the cable modem engine.

4. (Previously presented) A cable modem system as claimed in claim 1, and further comprising an advanced crypto engine configured to perform all crypto functions for both the data networking engine and the cable modem engine, the advanced crypto engine being separate from both the data networking engine and the cable modem engine.

5. (Previously presented) A cable modem system as claimed in claim 1, wherein the cable modem engine includes:

a DOCSIS PHY layer;

a DOCSIS MAC processor; and

a DOCSIS controller, and

wherein the at least one processor of the data networking engine is a RISC processor.

6. (Previously presented) A cable modem system as claimed in claim 5, wherein the DOCSIS PHY layer includes a hardware transmitter and receiver.

7. (Previously presented) A cable modem system as claimed in claim 5, wherein the DOCSIS MAC processor is configured to process downstream PDU packets and forward the processed packets directly to the data networking engine without the involvement of the DOCSIS controller in order to boost downstream throughput.

8. (Original) A cable modem system as claimed in claim 5, wherein all VoIP functionality is implemented in the DOCSIS controller.

9. (Original) A cable modem system as claimed in claim 8, wherein the VoIP functionality is in conformance with the PacketCable specification.

10. (Previously presented) A cable modem system as claimed in claim 5, wherein the data networking engine is configured to perform all data networking processing including advanced multi-port bridging routing with NAT/firewall and VPN, and home networking applications.

11. (Original) A cable modem system as claimed in claim 10, wherein the data networking engine comprises the entire embedded portal services functionality of the CableHome specification.

12. (Previously presented) A cable modem system as claimed in claim 5, wherein the cable modem engine includes:

the DOCSIS PHY layer includes a transmitter and receiver;

the DOCSIS MAC processor is configured to implement real-time MAC functions for both upstream and downstream communications; and

the DOCSIS controller is configured to implement VoIP functionality; and wherein

the data networking engine includes a RISC processor configured to implement a majority of data networking processing and home networking applications decoupled from the implementation of the MAC functions and the VoIP functionality of the cable modem engine.

13. (Previously presented) A cable modem architecture as claimed in claim 12, wherein the DOCSIS controller is configured to provide VoIP functionality in accordance with the PacketCable specification, wherein the data networking engine is configured to provide the embedded portal services functionality of the CableHome specification, and wherein the CableHome functionality provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine.

14. (Original) A cable modem architecture as claimed in claim 13, wherein the DOCSIS MAC processor is an ARM9TDMI-based RISC processor, and wherein the DOCSIS controller is an ARM940-based RISC processor.

15. (Original) A method for providing a flexible and partitioned cable modem gateway comprising: providing data and home networking functionality in a data networking engine; providing DOCSIS and VoIP functionality in a cable modem engine; and partitioning the data networking engine from the cable modem engine so that the data and home networking functionality is completely decoupled from the DOCSIS and VoIP functionality.

16. (Previously presented) A cable modem system as claimed in claim 5, wherein the data networking engine includes consumer provided equipment drivers including a USB driver and an Ethernet driver and the data networking engine is configured to provide the embedded portal services functionality of the CableHome specification, wherein the DOCSIS controller is configured to provide VoIP functionality in accordance with the PacketCable specification, and wherein the CableHome functionality provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine.

REMARKS/ARGUMENTS

Reconsideration of the subject application, as amended, is respectfully requested.

Claims 1-16 are pending in the subject application. Claim 1 has been amended to recite that the cable modem functions include interfacing with cable media. Support for this amendment is found in the implementation examples of Figures 1 and 2, and the illustrated interfaces to the HFC or RF external sources.

In the February 5, 2010 Office Action, made final, the Examiner rejected claims 1-16 under 35 USC 102(e) as being anticipated by Brooks (U.S. 2001/0039600) ("Brooks '600"). (See, Office Action, p. 3.) Claim 12 was rejected under 35 USC 112, first paragraph, as failing to comply with the written description. Claims 12-14 were rejected under 35 USC 112, second paragraph, as indefinite.

A Request to Withdraw Finality and Response to Final Office Action was filed on April 5, 2010 in which claims 1 and 12 were amended to address the Examiner's section 112 rejections, and it was pointed out that there was continued uncertainty as to how the Examiner was interpreting and applying the disclosures of Brooks '600 to the claims at issue. More specifically, it was pointed out that in Brooks '600, only two processors were disclosed. Therefore, from the Examiner's position that "the data networking engine and cable modem engines are represented in figures 1 and 2" (Office Action, p. 8), it would follow that one of the two processors corresponded to the networking engine, and the other of the two processors corresponded to the cable modem engine. It was further pointed out that while the discussion concerning Figure 2 in Brooks '600 paragraph 0042 makes clear that cable modem functions are performed by CMAC unit 224, if the cable modem engine is to contain a processor and perform CMAC functions as claimed, the cited cable modem engine must include circuitry

to connect one of the processors with the CMAC unit. It was noted, however, that because available connecting circuitry would be shared by both the one processor and the other processor, the asserted cable modem engine and home networking engine could not be completely partitioned as claimed.

In the Examiner's Advisory Action (notification date May 11, 2010) the Examiner withdrew the section 112 rejections, continued the finality of the 102(e) rejection, and provided a limited further explanation of his view of how the disclosure of Brooks '600 applies to the pending claims. However, despite this further explanation, it is still not clear as to what the Examiner considers to be the cable modem engine and the data networking engine in Brooks '600.

The Examiner explained that:

> Brooks' abstract, for example, discloses bifurcated processing architecture. The first processor processes information flowing to and from cable media interface circuitry. This constitutes the data networking engine, which performs the interacting with equipment, as claimed. The second processor performs the management of some message processing and scheduling, which constitutes cable modem functions other than those of the data networking engine (please see paragraph 0026). This the constitutes the cable modem engine, as claimed. Claim 9 of the Brooks reference further teaches partitioned processors, where the co-processor supports the processing of cable media and performs data transfer, and the first processor performs a plurality of other processing functions.

(Advisory Action Before Filing of an Appeal Brief, sheet 3.)

First of all, the Examiner's assertion that "[t]his constitutes the data networking engine, which performs the interacting with equipment, as claimed" appears to equate the "cable media interface circuitry" with the "customer provided equipment" of, for example, claim 1. Presumably, the Examiner is referring to the CMAC/CPHY block (114, 118, 224 and 228) of Fig. 2 as the cable media interface circuitry. However, Brooks '600 does not describe such blocks as customer provided equipment. Thus, it is not clear what the Examiner considers to correspond to "customer provided equipment" in Brooks '600.

Further, from the above explanation, it appears that the Examiner may be asserting that the cable modem engine includes second processor 104, that the data networking engine is first processor 102 (see Fig. 2), and that the CMAC/CPHY block (114, 118, 224 and 228) is also a part of the cable modem engine. However, processor 102 handles many cable modem functions (see Fig. 4, paragraphs 0053 to 0062), and is explicitly described as "programmed to implement the desired MAC functionality" (paragraph 0026). Paragraph 0025 states "[i]n the case of DOCSIS, typical MAC functionality includes MPEG and MCNS decoding and frame synchronization." On the other hand, processor 104 is described only as providing operating system support and that it "may manage some message processing and scheduling" (paragraph 0026, emphasis added). Thus, the Examiner's designation of the first processor as the "data networking engine" is at odds with the Brooks '600 description of processor 102 as being "programmed to implement the desired MAC functionality."

The Examiner's apparent designation of the first processor 102 in Brooks '600 as the "data networking engine," and the second processor 104 and the CMAC/CPHY block (114, 118, 224 and 228) as the "cable modem engine," further does not square with the claim 1 feature that "the cable modem functions performed by the cable modem engine are completely partitioned from the home networking functions performed by the data networking engine," and the claim 15 feature of "partitioning the data networking engine from the cable modem engine so that the data and home networking functionality is completely decoupled from the DOCSIS and VOIP functionality." This is because the CMAC/CPHY block (114, 118, 224 and 228) communicates with both the processors 102 and 104 by sharing the same data paths and sharing the same direct memory access controller. (See peripheral bus 112 – bridge 110 – system bus 108 in Fig. 1 and APB 214 – DMA Controller/ASB-APB Bridge 212 – ASB 210 in Fig. 2, and paragraphs 0034 and 0035).

Further, accepting the Examiner's assertion that first processor 102 handles data networking functionality, and considering the description of paragraphs 0025 and 0026 that processor 102 is programmed to implement the desired MAC functionality (which would include typical DOCSIS MAC functionality), leads to a conclusion that the Brooks '600 processor 102 does not implement a complete partitioning or a completely decoupled arrangement of the data networking engine from the cable modem engine.

Thus, Brooks '600 does not provide the complete partitioning or completely decoupled arrangement of the data networking engine from the cable modem engine that the Examiner apparently asserts it does.

For at least the above reasons, it is respectfully submitted that Brooks '600 does not teach or make obvious the claimed subject matter.

The Examiner also asserts that claim 9 of the Brooks reference:

> further teaches partitioned processors, where the co-processor supports the processing of cable media and performs data transfer, and the first processor performs a plurality of other processing functions.

(Advisory Action Before Filing of an Appeal Brief, sheet 3.)

It is respectfully submitted that the description that the "co-processor supports the processing of cable media <u>and</u> performs data transfer" (emphasis added) indicates that there is no partitioning of cable modem functionality from data networking functionality in the co-processor, but instead a combining of the same. Thus, claim 9 of Brooks '600 does not support the Examiner's rejection of the claims of the subject application.

In view of the above, it is respectfully submitted that the application is now in condition for allowance. The Examiner's reconsideration and further examination are respectfully requested.

The undersigned attorney would welcome an opportunity to discuss the claims as amended and Brooks '600 with the Examiner in order to better understand the Examiner's interpretation of the same, and to advance the subject application toward allowance.

Respectfully submitted,

DLA Piper LLP (US)

Dated: June 7, 2010

By: /Gerald T. Sekimura/
Gerald T. Sekimura
Reg. No. 30,103
Tel.: (415) 836-2500

Attn.: Patent Department
DLA Piper LLP (US)
555 Mission Street, Suite 2400
San Francisco, CA 94105-2933

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/675,566	09/30/2003	Gordon Y. Li	81373818US01-02CXT0070D	9980

94518 7590 09/02/2011
DLA PIPER LLP (US)
2000 UNIVERSITY AVENUE
EAST PALO ALTO, CA 94303

EXAMINER	
WINDER, PATRICE L	

ART UNIT	PAPER NUMBER
2452	

MAIL DATE	DELIVERY MODE
09/02/2011	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

PTOL-90A (Rev. 04/07)

Office Action Summary	Application No. 10/675,566	Applicant(s) LI ET AL.	
	Examiner PATRICE WINDER	Art Unit 2452	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *07 June 2010*.
2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.
3)☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
4)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

5)☒ Claim(s) *1-16* is/are pending in the application.
5a) Of the above claim(s) _____ is/are withdrawn from consideration.
6)☐ Claim(s) _____ is/are allowed.
7)☒ Claim(s) *1-16* is/are rejected.
8)☐ Claim(s) _____ is/are objected to.
9)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

10)☐ The specification is objected to by the Examiner.
11)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
12)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
a)☐ All b)☐ Some * c)☐ None of:
1.☐ Certified copies of the priority documents have been received.
2.☐ Certified copies of the priority documents have been received in Application No. _____.
3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on June 7, 2010 has been entered.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

Claims 1-2, 4-6, 10, 11, are rejected under 35 U.S.C. 103(a) as being unpatentable over Schain et al., US 6,944,706 B2 (hereafter referred to Schain).

Regarding claim 1, Schain taught a cable modem system (column 4, lines 12-21) comprising:

a data networking engine implemented in a first circuit that includes at least one processor (processing element), the data networking engine programmed with software that when executed by the at least one processor of the first circuit causes the data

networking engine to perform home networking functions including interfacing with customer provided equipment (column 4, lines 22-28);

a cable modem engine implemented in a second circuit that includes at least one processor, the second circuit being separate from the first circuit (column 10, lines 28-34), the cable modem engine programmed with software that when executed by the at least one processor of the second circuit causes the cable modem engine to perform cable modem functions other than the home networking functions performed by the data networking engine, the cable modem functions including interfacing with cable media (column 4, lines 28-43; column 8, lines 35-48), and the cable modem engine configured to enable upgrades to its software in a manner that is independent of upgrades to the software of the data networking engine (column 10, lines 28-34); and

a data bus that connects the data networking engine to the cable modem engine, wherein the cable modem functions performed by the cable modem engine are completely partitioned from the home networking functions performed by the data networking engine (column 9, lines 26-28). Schain does not specifically teach separate processing elements but suggests embodiments where the engines would be implemented in the separate processing elements (column 10, lines 10-20). It would have been obvious to one of ordinary skill in the art at the time the invention was made that incorporating separate processing elements would have been equivalent embodiment.

Regarding dependent claim 2, Schain taught all DOCSIS functions are localized in the cable modem engine (column 8, lines 49-51).

Regarding dependent claim 4, Schain taught a cable modem system further comprising an advanced crypto engine configured to perform all crypto functions for both the data networking engine and the cable modem engine, the advanced crypto engine being separate from both the data networking engine and the cable modem engine (column 12, lines 55-64).

Regarding dependent claim 5, Schain taught a cable modem engine includes: a DOCSIS PHY layer; a DOCSIS MAC processor; and a DOCSIS controller, and wherein the at least one processor of the data networking engine is a RISC processor (column 13, lines 26-36).

Regarding dependent claim 6, Schain taught DOCSIS PHY layer includes a hardware transmitter and receiver (column 7, lines 47-51).

Regarding dependent claim 10, Schain taught the data networking engine is configured to perform all data networking processing including advanced multi-port bridging routing with NAT/firewall and VPN, and home networking applications (column 11, lines 59-67; column 12, lines10).

Regarding dependent claim 11, Schain does not specifically teach the data networking engine comprises the entire embedded portal services functionality of the CableHome specification. “Official notice” is taken embedded portal services functionality CableHome specification is well known in the art. It would have been obvious to one of ordinary skill in the art at the time the invention was made that incorporating the CableHome specification in Schain’s data networking engine would

have improved effectiveness. The motivation would have been to provide new services in a standardized manner.

Claims 3, 8, 9, 12-16 are rejected under 35 U.S.C. 103(a) as being unpatentable over Schain as applied to claims 2, 5 above, and further in view of Winters et al., US 2006/0080650 A1 (hereafter referred to as Winters).

Regarding dependent claim 3, Schain does not specifically teach VoIP functionality is embedded in the cable modem engine. However, Winters taught VoIP functionality is embedded in the cable modem engine (paragraphs 5-6). It would have been obvious to one of ordinary skill in the at the time the invention was made that incorporating Winter's VoIP functionality in Schain's cable modem would have extended functionality. The motivation would have to expand Schain's functionality to include voice telephony and provide capabilities for other cable modem services.

Regarding dependent claim 8, Schain does not specifically teach all VoIP functionality is implemented in the DOCSIS controller. However, Winters taught VoIP functionality is implemented in the DOCSIS controller of a cable modem (paragraphs 5-6). It would have been obvious to one of ordinary skill in the at the time the invention was made that incorporating Winter's VoIP functionality in Schain's cable modem would have extended functionality. The motivation would have to expand functionality to include voice telephony and provide capabilities for other cable modem services.

Regarding dependent claim 9, Winters taught the VoIP functionality is in conformance with the PacketCable specification (paragraphs 5-6).

Regarding dependent claim 12, Schain taught the cable modem engine includes: the DOCSIS PHY layer includes a transmitter and receiver (column 7, lines 47-51); the DOCSIS MAC processor is configured to implement real-time MAC functions for both upstream and downstream communications (column 12, lines 25-38); and the DOCSIS controller is configured to implement other functionality (column 10, lines 54-62); and wherein the data networking engine includes a processing element configured to implement a majority of data networking processing and home networking applications decoupled from the implementation of the MAC functions and the other functionality of the cable modem engine (column 8, lines 35-48). Schain does not specifically teach the other functionality is VoIP functionality. However, Winters taught VoIP functionality is implemented in the DOCSIS controller of a cable modem (paragraphs 5-6). It would have been obvious to one of ordinary skill in the at the time the invention was made that incorporating Winter's VoIP functionality in Schain's cable modem would have extended functionality. The motivation would have to expand functionality to include voice telephony and provide capabilities for other cable modem services.

Regarding dependent claim 13, Winters taught the DOCSIS controller is configured to provide VoIP functionality in accordance with the PacketCable specification, wherein the data networking engine is configured to provide the embedded portal services functionality of the CableHome specification, and wherein the CableHome functionality provided by the data networking engine is completely

decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine (paragraphs 5-6).

Regarding dependent claim 14, Schain does not the DOCSIS MAC processor is an RISC processor, and wherein the DOCSIS controller is an RISC processor (column 13, lines 26-36). Schain does not specifically teach ARM940-based or ARM9TDMI-based. However, both models are from a well know processor family. It would have been obvious to one of ordinary skill in the art at the time the invention was made that incorporating ARM 940-based processors in Schain's RISC processors would have been an acceptable selection. The motivation would have been because ARM 940 based processors have similar advantages.

Regarding claim 15, Schain taught a method for providing a flexible and partitioned cable modem gateway comprising:

providing data and home networking functionality in a data networking engine (column 4, lines 22-28);

providing DOCSIS and other functionality in a cable modem engine (column 4, lines 28-43; column 8, lines 35-48); and

partitioning the data networking engine from the cable modem engine so that the data and home networking functionality is completely decoupled from the DOCSIS and other functionality (column 10, lines 6-15). Schain does not specifically teach the other functionality is VoIP functionality in accordance with the PacketCable specification. However, Winters taught VoIP functionality is implemented in the DOCSIS controller of a cable modem in accordance with PacketCable specification (paragraphs 5-6). It would

have been obvious to one of ordinary skill in the at the time the invention was made that incorporating Winter's VoIP functionality in Schain's cable modem would have extended functionality. The motivation would have to expand functionality to include voice telephony and provide capabilities for other cable modem services.

Regarding dependent claim 16, Schain taught the data networking engine includes consumer provided equipment drivers including a USB driver and an Ethernet driver (column 11, lines 9-15). Schain does not specifically teach the data networking engine comprises the entire embedded portal services functionality of the CableHome specification. "Official notice" is taken embedded portal services functionality CableHome specification is well known in the art. It would have been obvious to one of ordinary skill in the art at the time the invention was made that incorporating the CableHome specification in Schain's data networking engine would have improved effectiveness. The motivation would have been to provide new services in a standardized manner.

Schain does not specifically teach the other functionality is VoIP functionality in accordance with the PacketCable specification. However, Winters taught VoIP functionality is implemented in the DOCSIS controller of a cable modem in accordance with PacketCable specification (paragraphs 5-6). It would have been obvious to one of ordinary skill in the at the time the invention was made that incorporating Winter's VoIP functionality in Schain's cable modem would have extended functionality. The

motivation would have to expand functionality to include voice telephony and provide capabilities for other cable modem services.

In combination Schain-Winter the CableHome functionality provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine (column 10, lines 6-15).

Allowable Subject Matter

Claim 7 is objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

The following is a statement of reasons for the indication of allowable subject matter: the DOCSIS MAC processor is configured to process downstream PDU packets and forward the processed packets directly to the data networking engine without the involvement of the DOCSIS controller in order to boost downstream throughput.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to PATRICE WINDER whose telephone number is (571)272-3935. The examiner can normally be reached on Monday-Friday, 12:00 pm - 8:30 pm.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Thu V. Nguyen can be reached on 571-272-6967. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Patrice L Winder/
Primary Examiner, Art Unit 2452

August 29, 2011

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Appln. No.	:	10/675,566	Conf. No.:	9980
First Named Inventor	:	Gordon Y. Li		
Filed	:	September 30, 2003		
Art Unit	:	2452		
Examiner	:	Winder, Patrice L.		
Docket No.	:	348162-982350		

Title: Architecture For A Flexible And High-Performance Gateway Cable Modem

AMENDMENT AND RESPONSE TO OFFICE ACTION

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Madam:

In response to the Office action mailed September 2, 2011, please enter the amendments set forth below and consider the following remarks.

Amendments to the Claims are reflected in the listing of claims that begins on page 2 of this paper.

Remarks begin on page 9 of this paper.

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

1. (**Canceled**)

2. (**Currently Amended**) A cable modem system as claimed in claim [[1]] 7, wherein all DOCSIS functions are localized in the cable modem engine.

3. (**Original**) A cable modem system as claimed in claim 2, wherein VoIP functionality is embedded in the cable modem engine.

4. (**Currently Amended**) A cable modem system as claimed in claim [[1]] 7, and further comprising an advanced crypto engine configured to perform all crypto functions for both the data networking engine and the cable modem engine, the advanced crypto engine being separate from both the data networking engine and the cable modem engine.

5. (**Canceled**)

6. (**Currently Amended**) A cable modem system as claimed in claim [[5]] 7, wherein the DOCSIS PHY layer includes a hardware transmitter and receiver.

7. (**Currently Amended**) A cable modem system comprising: ~~as claimed in claim 5,~~

a data networking engine implemented in a first circuit that includes at least one processor, the data networking engine programmed with software that when executed by the at least one processor of the first circuit causes the data networking engine to

perform home networking functions including interfacing with customer provided equipment, wherein the at least one processor is a RISC processor;

a cable modem engine implemented in a second circuit that includes at least one processor, the second circuit being separate from the first circuit, the cable modem engine including a DOCSIS PHY layer, a DOCSIS controller, and a DOCSIS controller and programmed with software that when executed by the at least one processor of the second circuit causes the cable modem engine to perform cable modem functions other than the home networking functions performed by the data networking engine, the cable modem functions including interfacing with cable media, the cable modem engine configured to enable upgrades to its software in a manner that is independent of upgrades to the software of the data networking engine; and

a data bus that connects the data networking engine to the cable modem engine, wherein the cable modem functions performed by the cable modem engine are completely partitioned from the home networking functions performed by the data networking engine;

wherein the DOCSIS MAC processor is configured to process downstream PDU packets and forward the processed packets directly to the data networking engine without the involvement of the DOCSIS controller in order to boost downstream throughput.

8. (**Currently Amended**) A cable modem system as claimed in claim [[5]] 7, wherein all VoIP functionality is implemented in the DOCSIS controller.

9. (**Original**) A cable modem system as claimed in claim 8, wherein the VoIP functionality is in conformance with the PacketCable specification.

10. (**Currently Amended**) A cable modem system as claimed in claim [[5]] 7, wherein the data networking engine is configured to perform all data networking processing

including advanced multi-port bridging routing with NAT/firewall and VPN, and home networking applications.

11. (**Original**) A cable modem system as claimed in claim 10, wherein the data networking engine comprises the entire embedded portal services functionality of the CableHome specification.

12. (**Currently Amended**) A cable modem system as claimed in claim [[5]] <u>7</u>, wherein <u>with regard to</u> the cable modem engine ~~includes~~:

the DOCSIS PHY layer includes a transmitter and receiver;

the DOCSIS MAC processor is configured to implement real-time MAC functions for both upstream and downstream communications; and

the DOCSIS controller is configured to implement VoIP functionality; and wherein the data networking engine includes a RISC processor configured to implement a majority of data networking processing and home networking applications decoupled from the implementation of the MAC functions and the VoIP functionality of the cable modem engine.

13. (**Currently Amended**) A cable modem ~~architecture~~ <u>system</u> as claimed in claim 12, wherein the DOCSIS controller is configured to provide VoIP functionality in accordance with the PacketCable specification, wherein the data networking engine is configured to provide the embedded portal services functionality of the CableHome specification, and wherein the CableHome functionality provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine.

14. (**Currently Amended**) A cable modem ~~architecture~~ <u>system</u> as claimed in claim 13, wherein the DOCSIS MAC processor is an ARM9TDMI-based RISC processor, and wherein the DOCSIS controller is an ARM940-based RISC processor.

15. (**Currently Amended**) A method of ~~for~~ cable modem operation as claimed in claim 17, further comprising:

providing a flexible and partitioned cable modem gateway comprising:

providing data and home networking functionality in the data networking engine;

providing DOCSIS and VoIP functionality in the cable modem engine; and

partitioning the data networking engine from the cable modem engine so that the data and home networking functionality is completely decoupled from the DOCSIS and VoIP functionality.

16. (**Currently Amended**) A cable modem system as claimed in claim [[5]] 7, wherein the data networking engine includes consumer provided equipment drivers including a USB driver and an Ethernet driver and the data networking engine is configured to provide the embedded portal services functionality of the CableHome specification, wherein the DOCSIS controller is configured to provide VoIP functionality in accordance with the PacketCable specification, and wherein the CableHome functionality provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine.

17. (**New**) A method of cable modem operation comprising:

executing, via at least one processor of a first circuit that implements a data networking engine, first software that causes the data networking engine to perform home networking functions including interfacing with customer provided equipment, wherein the at least one processor is a RISC processor;

executing, via one or more processors of a second circuit that implements a cable modem engine programmed with second software, the second software to cause the cable modem engine to perform cable modem functions other than the home networking functions performed by the data networking engine, the cable modem

functions including interfacing with cable media, the cable modem engine configured to enable upgrades to its software in a manner that is independent of upgrades to the software of the data networking engine, wherein the second circuit is separate from the first circuit, and wherein the cable modem engine includes a DOCSIS PHY layer, a DOCSIS controller and a DOCSIS controller;

connecting, via a data bus, the data networking engine to the cable modem engine, wherein the cable modem functions performed by the cable modem engine are completely partitioned from the home networking functions performed by the data networking engine;

processing, via the DOCSIS MAC processor, downstream PDU packets and forwarding the processed packets directly to the data networking engine without the involvement of the DOCSIS controller in order to boost downstream throughput.

18. (**New**) A method as claimed in claim 17, further comprising:

providing VoIP functionality in accordance with the PacketCable specification in the DOCSIS controller; and

providing the embedded portal services functionality of the CableHome specification in the data networking engine;

wherein the CableHome functionality provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine.

19. (**New**) A method as claimed in claim 17, further comprising:

providing the embedded portal services functionality of the CableHome specification in the data networking engine; and

providing VoIP functionality in accordance with the PacketCable specification in the DOCSIS controller;

wherein the data networking engine includes consumer provided equipment drivers including a USB driver and an Ethernet driver; and

wherein the CableHome functionality provided by the data networking engine is completely decoupled from the PacketCable and DOCSIS functionality provided by the cable modem engine.

20. (**New**) A cable modem system comprising:

a data networking engine implemented in a first circuit that includes at least one processor, the data networking engine programmed with software that when executed by the at least one processor of the first circuit causes the data networking engine to perform home networking functions including interfacing with customer provided equipment;

a cable modem engine implemented in a second circuit that includes at least one processor, the second circuit being separate from the first circuit, the cable modem engine programmed with software that when executed by the at least one processor of the second circuit causes the cable modem engine to perform cable modem functions other than the home networking functions performed by the data networking engine, the cable modem functions including interfacing with cable media, and the cable modem engine configured to enable upgrades to its software in a manner that is independent of upgrades to the software of the data networking engine, the cable modem engine including a DOCSIS controller and a DOCSIS MAC processor, the DOCSIS MAC processor configured to process downstream PDU packets and forward the processed packets directly to the data networking engine without the involvement of the DOCSIS controller in order to boost downstream throughput; and

a data bus that connects the data networking engine to the cable modem engine, wherein the cable modem functions performed by the cable modem engine are completely partitioned from the home networking functions performed by the data networking engine.

21. (**New**) A cable modem system as claimed in claim 20, wherein all DOCSIS functions are localized in the cable modem engine.

22. (**New**) The cable modem system as claimed in claim 20 wherein the DOCSIS MAC processor is configured to implement real-time MAC functions for both upstream and downstream communications.

REMARKS

In reply to the non-final Office Action mailed September 2, 2011, please enter the amendments set forth above and consider the following remarks. By this response, Applicants cancel claims 1 and 5 without prejudice or disclaimer, amend claims 2, 4, 6-8, 10, 12-15, and 16, and present new claims 17-22. No new matter has been added. After entry of this paper, claims 2-4 and 6-22 will be pending in this application.

In the Office action, the Examiner (i) rejected claims 1-2, 4-6, 10 and 11 under 35 U.S.C. 103(a), as being anticipated by Schain et al. (US 6,944,706 B2); (ii) rejected claims 3, 8, 9, 12-16 under 35 U.S.C. 103(a) as being unpatentable over Schain et al. as applied to claims 2, 5 above, and further in view of Winters et al. (US 2006/0080650 A1). With regard to the rejections, Applicants respectfully traverse, submitting that the standing rejections are unsupportable/moot/overcome as against the claims presented for at least the reasons set forth below. Reconsideration is respectfully requested.

Claim Rejections Under 35 USC § 103 (a)

Claims 1-2, 4-6, 10 and 11 stand rejected under 35 U.S.C. 103(a), as being anticipated by Schain et al. (US 6,944,706 B2).

Claims 3, 8, 9, 12-16 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Schain et al. as applied to claims 2, 5 above, and further in view of Winters et al. (US 2006/0080650 A1).

Applicants respectfully traverse these rejections.

As an initial matter, Applicants have canceled claims 1 and 5 without prejudice or disclaimer, and respectfully submit the rejections against these claims are moot..

Further and without acquiescence, in the interests, e.g., of advancing the prosecution of this case, avoiding additional costs, etc., Applicants have canceled the rejected claims, or amended the claims to depend from a claim indicated as allowable by the Examiner. Accordingly, Applicants submits that the rejections are moot or now unsupported in view of the amended claims, and respectfully request that they be withdrawn.

Specifically, the Examiner indicates on page 9 of the Office Action that claim 7 is allowable if rewritten in independent form. Claim 7 has been rewritten in independent

form, and claims 2-4, 6, 8-14, and 16 depend directly or indirectly on claim 7. Independent claim 15 has been amended to depend on new claim 17 which recites subject matter indicated as allowable by the Examiner (*see, e.g.,* Office Action, pg. 9).

New Claims

Claims 17-22 are new claims presented in place of the claims canceled by Applicant without prejudice or disclaimer. New claims 17-22 are either copies of existing claims (with different dependencies or additional language) or are new claims reciting features indicated to be patentable. Further, all of these claims either depend on allowable claims or recite subject matter consistent with existing allowable claims. Accordingly, Applicants respectfully submit that these new claims present no new matter, and are allowable for at least the same reasons as their related claims.

Closing Remarks

In view of the above, it is respectfully submitted that the claims are now in condition for formal allowance, and early and favorable action to that end is respectfully requested.

The Examiner is encouraged to call Applicants' attorney at the number below if doing so will in any way advance the prosecution of this application.

The Commissioner is hereby petitioned to grant any extensions of time required to enter this paper as well as authorized to charge any fees which may be required, or credit in the overpayment, to Deposit Account No. 07-1896 referencing Attorney Docket No. 348162-982350.

Respectfully submitted,

DLA PIPER US LLP

Dated: March 2, 2012

By: /Andy Schwaab/
Andrew B. Schwaab
Reg. No. 38,611
Attorneys for Applicant

DLA PIPER US LLP
2000 University Avenue
East Palo Alto, CA 94303
Atty direct (650) 833-2258

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

94518 7590 03/19/2012

DLA PIPER LLP (US)
2000 UNIVERSITY AVENUE
EAST PALO ALTO, CA 94303

EXAMINER	
WINDER, PATRICE L	
ART UNIT	PAPER NUMBER
2452	

DATE MAILED: 03/19/2012

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/675,566	09/30/2003	Gordon Y. Li	348162-982350	9980

TITLE OF INVENTION: ARCHITECTURE FOR A FLEXIBLE AND HIGH-PERFORMANCE GATEWAY CABLE MODEM

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1740	$300	$0	$2040	06/19/2012

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the SMALL ENTITY status shown above.

If the SMALL ENTITY is shown as YES, verify your current SMALL ENTITY status:

A. If the status is the same, pay the TOTAL FEE(S) DUE shown above.

B. If the status above is to be removed, check box 5b on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and twice the amount of the ISSUE FEE shown above, or

If the SMALL ENTITY is shown as NO:

A. Pay TOTAL FEE(S) DUE shown above, or

B. If applicant claimed SMALL ENTITY status before, or is now claiming SMALL ENTITY status, check box 5a on Part B - Fee(s) Transmittal and pay the PUBLICATION FEE (if required) and 1/2 the ISSUE FEE shown above.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed and an extra copy of the form should be submitted. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Utility patents issuing on applications filed on or after Dec. 12, 1980 may require payment of maintenance fees. It is patentee's responsibility to ensure timely payment of maintenance fees when due.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), to: Mail **Mail Stop ISSUE FEE**
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450
or Fax (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications.

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

94518 7590 03/19/2012

DLA PIPER LLP (US)
2000 UNIVERSITY AVENUE
EAST PALO ALTO, CA 94303

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being facsimile transmitted to the USPTO (571) 273-2885, on the date indicated below.

(Depositor's name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/675,566	09/30/2003	Gordon Y. Li	348162-982350	9980

TITLE OF INVENTION: ARCHITECTURE FOR A FLEXIBLE AND HIGH-PERFORMANCE GATEWAY CABLE MODEM

APPLN. TYPE	SMALL ENTITY	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	NO	$1740	$300	$0	$2040	06/19/2012

EXAMINER	ART UNIT	CLASS-SUBCLASS
WINDER, PATRICE L	2452	370-401000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).
   - ❑ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
   - ❑ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list
   (1) the names of up to 3 registered patent attorneys or agents OR, alternatively,
   (2) the name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.
   1 ____________
   2
   3 ____________

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document has been filed for recordation as set forth in 37 CFR 3.11. Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ❑ Individual ❑ Corporation or other private group entity ❑ Government

4a. The following fee(s) are submitted:
- ❑ Issue Fee
- ❑ Publication Fee (No small entity discount permitted)
- ❑ Advance Order - # of Copies ____________

4b. Payment of Fee(s): **(Please first reapply any previously paid issue fee shown above)**
- ❑ A check is enclosed.
- ❑ Payment by credit card. Form PTO-2038 is attached.
- ❑ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account Number ____________ (enclose an extra copy of this form).

5. **Change in Entity Status** (from status indicated above)
- ❑ a. Applicant claims SMALL ENTITY status. See 37 CFR 1.27.
- ❑ b. Applicant is no longer claiming SMALL ENTITY status. See 37 CFR 1.27(g)(2).

NOTE: The Issue Fee and Publication Fee (if required) will not be accepted from anyone other than the applicant; a registered attorney or agent; or the assignee or other party in interest as shown by the records of the United States Patent and Trademark Office.

Authorized Signature ____________ Date ____________

Typed or printed name ____________ Registration No. ____________

This collection of information is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/675,566	09/30/2003	Gordon Y. Li	348162-982350	9980

94518 7590 03/19/2012

DLA PIPER LLP (US)
2000 UNIVERSITY AVENUE
EAST PALO ALTO, CA 94303

EXAMINER	
WINDER, PATRICE L	
ART UNIT	PAPER NUMBER
2452	

DATE MAILED: 03/19/2012

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b)
(application filed on or after May 29, 2000)

The Patent Term Adjustment to date is 1748 day(s). If the issue fee is paid on the date that is three months after the mailing date of this notice and the patent issues on the Tuesday before the date that is 28 weeks (six and a half months) after the mailing date of this notice, the Patent Term Adjustment will be 1748 day(s).

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Application Information Retrieval (PAIR) WEB site (http://pair.uspto.gov).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

PTOL-85 (Rev. 02/11)

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

Notice of Allowability	Application No. 10/675,566	Applicant(s) LI ET AL.	
	Examiner PATRICE WINDER	Art Unit 2452	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to *3-2-2012*.
2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.
3. ☒ The allowed claim(s) is/are *2-4 and 6-22*.
4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
   a) ☐ All b) ☐ Some* c) ☐ None of the:
   1. ☐ Certified copies of the priority documents have been received.
   2. ☐ Certified copies of the priority documents have been received in Application No. _____ .
   3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

   * Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ A SUBSTITUTE OATH OR DECLARATION must be submitted. Note the attached EXAMINER'S AMENDMENT or NOTICE OF INFORMAL PATENT APPLICATION (PTO-152) which gives reason(s) why the oath or declaration is deficient.
6. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
   (a) ☐ including changes required by the Notice of Draftsperson's Patent Drawing Review (PTO-948) attached
   1) ☐ hereto or 2) ☐ to Paper No./Mail Date _____.
   (b) ☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

   Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).
7. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☐ Notice of References Cited (PTO-892)
2. ☐ Notice of Draftperson's Patent Drawing Review (PTO-948)
3. ☐ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____
4. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material
5. ☐ Notice of Informal Patent Application
6. ☐ Interview Summary (PTO-413), Paper No./Mail Date _____ .
7. ☐ Examiner's Amendment/Comment
8. ☐ Examiner's Statement of Reasons for Allowance
9. ☐ Other _____.

/Patrice L Winder/
Primary Examiner, Art Unit 2452

Appendix H

IEEE 100
The Authoritative Dictionary of IEEE Standards Terms

Seventh Edition

IEEE
Published by
Standards Information Network
IEEE Press

Trademarks and disclaimers

IEEE believes the information in this publication is accurate as of its publication date; such information is subject to change without notice. IEEE is not responsible for any inadvertent errors.

Other tradenames and trademarks in this document are those of their respective owners.

The Institute of Electrical and Electronics Engineering, Inc.
3 Park Avenue, New York, NY, 10016-5997, USA

To order IEEE Press publications, call 1-800-678-IEEE.

Print: ISBN 0-7381-2601-2 *SP1122*

See other standards and standards-related product listings at: http://standards.ieee.org/

Library of Congress Cataloging-in-Publication Data

IEEE 100 : the authoritative dictionary of IEEE standards terms.—7th ed.
p. cm.
ISBN 0-7381-2601-2 (paperback : alk. paper)
1. Electric engineering—Dictionaries. 2. Electronics—Dictionaries. 3. Computer engineering—Dictionaries. 4. Electric engineering—Acronyms. 5. Electronics—Acronyms. 6. Computer engineering—Acronyms. I. Institute of Electrical and Electronics Engineers.

TK9 .I28 2000
621.3'03—dc21 00-050601

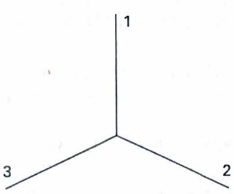
$115.55 IEEE 10-19-05

direction of lay (cable) The lateral direction, designated as left-hand or right-hand, in which the elements of a cable run over the top of the cable as they recede from an observer looking along the axis of the cable. (PE/T&D) [4], [10]

direction of polarization (of an elliptically polarized wave) The direction of the major axis of the electric vector ellipse. *See also:* elliptically polarized wave. (AP/PROP) 211-1997

direction of propagation (1) (A) (point in a homogeneous isotropic medium) The normal to an equiphase surface taken in the direction of increasing phase lag. *See also:* radiation. **(B) (point in a homogeneous isotropic medium)** The direction of time-average energy flow. *Notes:* 1. In a uniform waveguide the direction of propagation is often taken along the axis.X. 2. The directional response pattern is often shown as the response relative to the maximum response. *See also:* waveguide; radiation. (PE/EEC/MTT) [119], 146-1980
(2) (waveguide) The direction of time average energy flow in a given mode. *Note:* In the case of a uniform lossless waveguide, the direction of propagation at every point is parallel to the axis. (MTT) 146-1980w
(3) At any point in a medium, the direction of the time-averaged energy flow. *See also:* Poynting vector. (AP/PROP) 211-1997

direction of rotation of phasors (power and distribution transformers) Phasor diagrams should be drawn so that an advance in phase of one phasor with respect to another is in the counterclockwise direction. In the following figure, phasor 1 is 120 degrees in advance of phasor 2, and the phase sequence is 1, 2, 3.



direction of rotation of phasors

(PE/TR) C57.12.80-1978r

direction operation Operation by means of a mechanism connected directly to the main operating shaft or an extension of the same. (SWG/PE) [56], C37.100-1992, C37.30-1971s, C37.100-1981s

directive A line from a file that is interpreted by the batch server. The line is usually in the form of a comment and is an additional means of passing options to the `qsub` utility. (C/PA) 1003.2d-1994

directive gain* *See:* directivity.

* Deprecated.

directive gain in physical media In a given direction and at a given point in the far field, the ratio of the power flux per unit area from an antenna to the power flux per unit area from an isotropic radiator at a specified location delivering the same power from the antenna to the medium. *Note:* The isotropic radiator must be within the smallest sphere containing the antenna. Suggested locations are antenna terminals and points of symmetry if such exist. (AP/ANT) 145-1983s

directivity (1) (gain) The value of the directive gain in the direction of its maximum value. *See also:* antenna. (AP) 149-1979r
(2) (directional coupler) The ratio of the power output at an auxiliary port, when power is fed into the main waveguide or transmission line in the preferred direction, to the power output at the same auxiliary port when power is fed into the main guide or line in the opposite direction, the incident power fed into the main guide or line being the same in each case, and reflectionless terminations being connected to all ports. *Note:* The ratio is usually expressed in decibels. (IM/HFIM) [40]
(3) (of an antenna) (in a given direction) The ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged over all directions. *Notes:* 1. The average radiation intensity is equal to the total power radiated by the antenna divided by 4π. 2. If the direction is not specified, the direction of maximum radiation intensity is implied. (AP/ANT) 145-1993

directivity factor (A) (transducer used for sound emission) (audio and electroacoustics) The ratio of the sound pressure squared, at some fixed distance and specified direction, to the mean-square sound pressure at the same distance averaged over all directions from the transducer. *Notes:* 1. The distance must be great enough so that the sound pressure appears to diverge spherically from the effective acoustic center of the transducer. Unless otherwise specified, the reference direction is understood to be that of a maximum response. The frequency must be stated. **(B) (transducer used for sound reception)** The ratio of the square of the open-circuit voltage produced in response to sound waves arriving in a specified direction to the mean-square voltage that would be produced in a perfectly diffused sound field of the same frequency and mean-square sound pressure. *Notes:* 1. This definition may be extended to cover the case of finite frequency bands whose spectrum may be specified. 2. The average free-field response may be obtained in various ways, such as by the use of a spherical integrator, by numerical integration of a sufficient number of directivity patterns corresponding to different planes, or by integration of one or two directional patterns whenever the pattern of the transducer is known to possess adequate symmetry. *See also:* microphone. (SP) [32]

directivity, partial *See:* partial directivity.

direct lighting (illuminating engineering) Lighting involving luminaires which distribute 90 to 100 percent of the emitted light in the general direction of the surface to be illuminated. The term usually refers to light emitted in a downward direction. (EEC/IE) [126]

direct liquid cooling system (semiconductor rectifiers) A cooling system in which a liquid, received from a constantly available supply, is passed directly over the cooling surfaces of the semiconductor power converter and discharged. *See also:* semiconductor rectifier stack. (IA) [62]

direct liquid cooling system with recirculation (semiconductor rectifiers) A direct liquid cooling system in which part of the liquid passing over the cooling surfaces of the semiconductor power converter is recirculated and additional liquid is added as needed to maintain the required temperature, the excess being discharged. *See also:* semiconductor rectifier stack. (IA) [62]

direct lookup A table lookup in which the position of an entry is computed as a function of its key value. (C) 610.5-1990w

directly controlled system That portion of the controlled system that is directly guided or restrained by the final controlling element to achieve a prescribed value of the directly controlled variable. *See also:* feedback control system. (IM/IA/IAC) [120], [60]

directly controlled variable (automatic control) The variable in a feedback control system whose value is sensed to originate the primary feedback signal. *See also:* feedback control system. (PE/ICTL/EDPG) 421-1972s

Directly Executable Test Oriented Language (DETOL) A test language used to control a specific type of automatic test equipment. (C) 610.13-1993w

directly grounded *See:* grounded solidly.

direct manipulation User manipulation of symbols in the display by direct interaction with the symbol. It is generally performed through the use of a display structure, such as a pointer, and a cursor control device, such as a mouse. (PE/NP) 1289-1998

direct memory access (DMA) (1) Access to data by which data is transferred directly between main memory and storage devices. (C) 610.5-1990w
(2) Ability of I/O controller modules to independently access memory. An I/O controller with DMA capabilities can access

commands, fetch data, and report status by accessing memory directly. (C/BA) 896.3-1993w
(3) A method for transferring data between an external device and memory without interrupting program flow or requiring CPU intervention. *Note:* The interface device takes control of the memory and transfers the data. *See also:* programmed input-output; direct memory transfer. (C) 610.10-1994w
(4) This refers to the ability of I/O controller modules to independently access memory. An I/O controller with DMA capabilities can access commands, fetch data, and report status by accessing memory directly. (C/BA) 896.4-1993w

direct memory access controller (DMAC) The block transfer processor used to implement direct memory access. (C) 610.5-1990w

direct memory control (DMC) *See:* direct memory transfer.

direct memory transfer (DMT) A method for transferring data between an external device and memory without interrupting program flow. *Note:* The CPU microcode flow is changed to a routine which transfers the data. *Synonym:* direct memory control. *See also:* direct memory access; programmed input-output. (C) 610.10-1994w

direct metric A metric that does not depend upon a measure of any other attribute. (C/SE) 1061-1998

direct metric value A numerical target for a quality factor to be met in the final product. For example, mean time to failure (MTTF) is a direct metric of final system reliability. (C/SE) 1061-1998

direct numerical control Numerical control in which a dedicated computer controls the operation of the parts programs in a single numerical control machine. (C) 610.2-1987

direct on-line starting (rotating machinery) The process of starting a motor by connecting it directly to the supply at a rated voltage. *See also:* asynchronous machine. (PE) [9]

direct operation Operation by means of a mechanism connected directly to the main operating shaft or an extension of the same. (SWG/PE) C37.30-1971s, C37.100-1992, [56], C37.100-1981s

direct orbit (communication satellite) An inclined orbit with an inclination between zero and ninety degrees. (COM) [19]

director element (1) (data transmission) A parasitic element located forward of the driven element of an antenna, intended to increase the directive gain of the antenna in the forward direction. (PE) 599-1985w
(2) A parasitic element located forward of the driven element of an antenna, intended to increase the directivity of the antenna in the forward direction. (AP/ANT) 145-1993

directory (1) (A) A list of data items and information about those items, used to reference the items; for example, the directory for each user's personal disk space contains an entry for each file within that space, and a reference to its physical location. *Contrast:* dictionary. *See also:* data directory; file directory. **(B)** *See also:* index. (C) 610.5-1990, 610.12-1990
(2) A contiguous collection of one or more entries, which is contained within the node's ROM. (C/MM) 1212-1991s
(3) A file that contains directory entries. No two directory entries in the same directory shall have the same name. (C/PA) 9945-1-1996, 9945-2-1993
(4) A repository of information about objects that provides directory services to its users, which allows its users access to the information. (PA/C) 1328.2-1993w, 1224.2-1993w, 1327.2-1993w, 1326.2-1993w
(5) A file that contains directory entries. No two entries in a directory shall have the same filename. (C) 1003.5-1999

directory-assistance call (telephone switching systems) A call placed to request the directory number of a customer. (COM) 312-1977w

directory attribute The information of a particular type concerning an object and appearing in an entry describing the object in the DIB. *Synonym:* attribute. (C/PA) 1328.2-1993w, 1327.2-1993w, 1224.2-1993w, 1326.2-1993w

directory attribute type That component of a directory attribute that indicates the class of information given by that attribute. It is an object identifier, and so completely unique. *Synonym:* attribute type. (C/PA) 1328.2-1993w, 1224.2-1993w, 1327.2-1993w, 1326.2-1993w

directory attribute value A particular instance of the class of information indicated by a directory attribute type. *Synonym:* attribute value. (C/PA) 1328.2-1993w, 1224.2-1993w, 1327.2-1993w, 1326.2-1993w

directory class *See:* object class.

directory entry (1) A ROM entry that specifies the address of another ROM directory. (C/MM) 1212-1991s
(2) An object that associates a filename with a file. Several directory entries can associate names with the same file. *Synonym:* link. (C/PA) 9945-1-1996, 9945-2-1993
(3) An object that associates a filename with a file. Several directory entries can associate different filenames with the same file. (C) 1003.5-1999

directory information base The complete set of information to which the directory provides access and that includes all of the pieces of information that can be read or manipulated using the operations of the directory. (C/PA) 1328.2-1993w, 1224.2-1993Ow, 1326.2-1993w, 1327.2-1993w

directory information tree The directory information base, considered as a tree, whose vertices (other than the root) are the directory entries. (C/PA) 1328.2-1993w, 1326.2-1993w, 1327.2-1993w, 1224.2-1993w

directory medium A medium that contains a distribution in a POSIX.1 hierarchical file system format. (C/PA) 1387.2-1995

directory number (telephone switching systems) The full complement of digits required to designate a customer in a directory. (COM) 312-1977w

directory-numbering plan (telephone switching systems) The arrangement whereby each customer is identified by an office and main-station code. (COM) 312-1977w

directory object Anything in some "world," generally the world of telecommunications and information processing or some part thereof, that is identifiable (can be named) and that it is of interest to hold information on in the directory information base. (C/PA) 1326.2-1993w, 1327.2-1993w, 1224.2-1993w, 1328.2-1993w

directory operation Processing performed within the directory to provide a service, such as a read directory operation; it is given some arguments as input, performs some processing, and returns some results. An application process causes a directory operation to be performed by invoking an interface operation. (C/PA) 1328.2-1993w, 1327.2-1993w, 1326.2-1993w, 1224.2-1993w

directory syntax *See:* attribute syntax.

directory system agent An OSI application process that is part of the directory. (C/PA) 1328.2-1993w, 1326.2-1993w, 1327.2-1993w, 1224.2-1993w

directory user agent An OSI application process that represents a user accessing the directory. *Note:* This may be composed of an arbitrary number of system processes and application processes, including the one or more that are the user(s). (C/PA) 1328.2-1993w, 1327.2-1993w, 1224.2-1993w, 1326.2-1993w

Appendix I

NEWTON's TELECOM DICTIONARY

STAY INFORMED

To be alerted by email to news, updates and corrections send a blank email to newton@news.cmpbooks.com or go to www.cmpbooks.com/newton

CMPBooks
San Francisco

NEWTON's TELECOM DICTIONARY

email: Harry@HarryNewton.com
personal web site: www.HarryNewton.com
business web site: www.InSearchOfThePerfectInvestment.com

Published in the United States by
CMP Books
An imprint of CMP Media LLC
600 Harrison Street, San Francisco, CA 94107
Phone: 415-947-6615; Fax: 415-947-6015
Email: books@cmp.com
www.cmpbooks.com

CMP
United Business Media

For individual or quantity orders
CMP Books
6600 Silacci Way Gilroy, CA 95020
Tel: 1-800-500-6875 or 1-408-848-5296
Email: bookorders@cmp.com; Web: www.cmpbooks.com

This book is also sold through www.Amazon.com, www.Fatbrain.com and www.BarnesAndNoble.com and all fine booksellers worldwide.

Distributed to the book trade in the U.S. by
Publishers Group West
1700 Fourth St., Berkeley, CA 94710

Distributed in Canada by:
Jaguar Book Group, 100 Armstrong Avenue, Georgetown, Ontario M6K 3E7 Canada

Printed in the United States of America

ISBN Number 1-57820-309-0

March 2004

Twentieth Edition

Matt Kelsey, Publisher
Ray Horak, Senior Contributing Editor
Frank Brogan, Project manager
Saul Roldan and Damien Castaneda, Cover Design
Brad Greene, Text Layout

reference level for the voltages of all other signals (such as RXD/TXD), except Frame Ground.

Signal Level The strength of a signal, generally expressed in either absolute units of voltage or power, or in units relative to the strength of the signal at its source.

Signal Processing Signal processing is a combination of computer telephony call control and media processing. Call control means moving telephone calls around — answering them, hanging up on them, transferring them, conferencing them, etc. — all the stuff you do on your office phone every day. Media processing means bringing computer power to bear on the media stream, the actual voice, video or data inside the phone call. You might save it to your hard disk. You might want to have your PC software listen for key words in what you saved, for example, the caller's phone number. You might even want your software to try transcribing the conversation into text you could use in your word processor. See Call Control, Digital Signal Processing, Media Processing and Native Signal Processing.

Signal Processing Component An SCSA definition. An atomic bundle of signal processing functionality which can be allocated to a single group. It can be capable of supporting the functionality of one or more resources or a simple coder.

Signal Processing Element An SCSA definition. That part of a Signal Processing Component which is associated with a single Resource.

Signal Processing Platform A SCSA definition. This is a software component that supports a specific hardware package. This is typically an executable program and may control one or more instances of the vendor-specific hardware package. Each SPP may support several different types of signal processing functionality clustered into SPCs.

Signal Repeaters A signal repeater does nothing more than receive a signal and retransmit it. Repeaters are used where the original transmission is very weak, or the transmission is being sent over long distances.

Signal Strength Indicator A display on a cellular radio that lets you know before you call about the relative strength of the cellular transmitter in your immediate area. On most cellular radios, the signal strength indicator has five bars, with five the strongest. It's best to call when you have four or five. Three is marginal. Below three, forget it. Go elsewhere and try again.

Signal Switching Point SSP. See SSP. For a full explanation of the Advanced Intelligent Network, see AIN.

Signal-to-noise-ratio 1. Often abbreviated as SNR or S/N. A measurement of the relative level of noise on a circuit and, therefore, the quality of a transmission, SNR is the ratio of the usable signal being transmitted to the noise or undesired signal. Human beings are fairly tolerant of noise, and within limits, can distinguish content from the "noise," but computer systems are not. If the level of extraneous noise is high in a data communications environment, data packets have to be re-sent. That not only slows down the data transfer, but also reduces the efficiency with which the circuit and network are used. SNR usually is measured in decibels (dB). See also dB.

2. The ratio between useful information and idle chatter to be found on an Internet Usenet newsgroup, bulletin board, or chat room. Often used derogatorily, for example: "The signal-to-noise ratio in this newsgroup is pretty low."

Signal Transfer Point The packet switch in the Common Channel Interoffice Signaling (CCIS) system. The CCIS is a packet switched network operating at 4800 bits per second. CCIS replaces both SF (Single Frequency) and MF (Multi-frequency) by converting dialed digits to data messages. See SCP, STP and Signaling System 7. For a full explanation of the Advanced Intelligent Network, see AIN.

Signals Signal being transmitted are information. They can be spoken words such as a telephone conversation, music, or even computer data. The simplest signal we can send is a sine wave. All sound waves are combinations of simpler sine waves at different amplitudes and frequencies to produce complicated wave forms. Similarly, computer data is a series of ones and zeros which electrically look like a square wave. Square waves, like all other types of waves, can be represented by a combination of sine waves with different frequencies and amplitudes. That a complex wave is the sum of simple sine waves was discovered by the French mathematician Jean Baptiste Joseph Fourier and is called Fourier's Theorem.

Signals Intelligence SIGINT. A federal government term. A category of intelligence information comprising, either individually or in combination, all communications intelligence, electronics intelligence, and foreign instrumentation signals intelligence, however transmitted. Signals intelligence is a polite term for reading someone else's mail. See NSA and SIGINT.

Signaling In any telephone system — inside an office or across the country — some form of signaling mechanism is required to set up and tear down the calls. When you call from your office desk across the country to someone else's desk, many forms of different signaling are used. There's the signaling between your office desk phone and your office phone system. There's the signaling between your office phone system and your local telephone company central office. And there's the signaling between your local central office and the central office you're trying to reach across the country. All forms of these signaling may be different. Simple examples of signalings are ringing of your phone (someone is calling), dial tone (it's OK to dial), ringing (hopefully someone will answer), etc.

Originally, telephone systems such as POTS (Plain Old Telephone Service) used in-band signaling to carry signals. With in-band signaling, signals such as DTMF tones (touchtones), are carried in the same circuit as the talk path. Newer signaling (i.e. most of it today) is carried as out-of-band signaling, which uses a separate data network. This is much more efficient. For example, voice circuits need not be allocated for calls that do not complete. Also, this approach allows additional quantities of information to be transferred to support advanced applications such as Caller ID, roaming in wireless systems, and 800 number routing. See Signaling System 7.

Signaling Connection Control Part SCCP. Part of the SS7 protocol that provides communication between signaling nodes by adding circuit and routing information to the signaling message. The ISDN-UP (Integrated Services Digital Network User Part) and TCAP (Transaction Capabilities Application Part) use the SCCP (Signaling Connection Control Part) and the MTP (Message Transfer Part) to transport information. Definition from Bellcore in reference to its concept of the Advanced Intelligent Network.

Signaling Gateway SG. A software-based device that resolves interface issues between circuit-switched and packet-switched networks. See also MGCP and SCTP.

Signaling Information Fields SIF. In SS7 (Signaling System 7) signaling messages, the SIF is a variable length field which contains all the signaling information. Also included is any routing information in the Routing Label, which the network uses to properly connect the call. Such signaling information might include the Calling Party Number (CPN) subfield, along with the Presentation Indicator (PI). The SIF contains 2-272 octets of data. See also Calling Party Number, Presentation Indicator, and SS7.

Signaling Link Selection Code SLS. The part of a routing label that identifies the SS7 signaling link on which the message should be sent.

Signaling Point A node in a SS7 signaling network that either originates and receives signaling messages, or transfers signaling messages from one signaling link to another, or both. SPs are located at each switch in a Signaling System 7 network. They interface the switch with the Signal Transfer Points (STPs). See Signal Transfer Points and Signaling System 7.

Signaling Point Code A binary code uniquely identifying a SS7 signaling point in a signaling network. This code is used, according to its position in the label, either as destination point code or as originating point code.

Signaling Point Interface SPOI. The demarcation point on the SS7 signaling link between a LEC network and a Wireless Services Provider (WSP) network. The point established the technical interface and can designate the test point and operational division of responsibility for the signaling.

Signaling System Number 1 SS1. A tone supervision system using a 500 Hertz tone modulated at a 20 Hertz rate to signal call requests between switchboards. International equivalent of Bell's 1000/20 manual ringdown signaling. Now obsolete.

Signaling System Number 2 SS2. A two-tone (600/750 Hertz) tone system for dial-pulsing selection information. Never used internationally. Closely akin to early Bell mobile radiotelephone dialing systems. Now obsolete.

Signaling System Number 3 SS3. A single-frequency (2280 Hertz) tone system used on one-way circuits only. Not intended for transit connections involving a third nation. A prime method through the late 1970s. Now obsolete.

Signaling System Number 4 SS4. A two-tone (2040 and 2400 Hertz) system for international transit and terminal traffic. The first truly global "direct dialing" signaling system. Now obsolete.

Signaling System Number 5 SS5. A two-tone (2400 and 2600 Hertz) system combined with multifrequency inter-register signaling for both terminal and transit traffic. Closest international equivalent to North American Bell "DDD trunks using SF supervision." Now obsolete.

Signaling System Number 6 SS6. A common digital data path between two switching machines to negotiate and oversee connection control on transmission facil-